LONG RANGE SEISMIC MEASUREMENTS

BRONZE

23 JULY 1965

Prepared for

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Washington, D. C.

3 DECEMBER 1965

By

UED EARTH SCIENCES DIVISION
TELEDYNE, INC.

Under

Project VELA UNIFORM

Sponsored By

ADVANCED RESEARCH PROJECTS AGENCY

Nuclear Test Detection Office

ARPA Order No. 624

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LONG RANGE SEISMIC MEASUREMENTS

BRONZE

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SEISMIC DATA LABORATORY REPORT NO. 132

AFTAC Project No.:	VELA T/2037
Project Title:	Seismic Data Laboratory
ARPA Order No.:	624
ARPA Program Code No.:	5810
Name of Contractor:	UED EARTH SCIENCES DIVISION TELEDYNE, INC.
Contract No :	AF 33(657)-12447
Date of Contract:	17 August 1963
Amount of Contract:	$ 5,382,624
Contract Expiration Date:	17 February 1966
Project Manager:	Robert Van Nostrand (703) 836 - 7644

P. O. Box 334, Alexandria, Virginia

AVAILABILITY

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This research was supported by the Advanced Research Projects Agency, Nuclear Test Detection Office, and was monitored by the Air Force Technical Applications Center under Contract AF 33(657) 12447.

TABLE OF CONTENTS

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BRONZE

EVENT DESCRIPTION

DATE:	23 July 1965
TIME OF ORIGIN:	17:00:00.0Z
YIELD:	
MAGNITUDE:	5.22 ± 0.32

LOCATION:

Site: Nevada Test Site - Area U7f

Geographic Coordinates:

Lat: 37°05'52" N

Long: 116°01'59" W

ENVIRONMENT:

Geologic Medium:	Tuff
Shot Depth:	1750 Feet
Surface Elevation:	4213 Feet
Shot Elevation:	2463 Feet

COMPUTED EPICENTER:

Geographic Coordinates:

Lat: 37°00'47" N

Long: 116°08'56" W

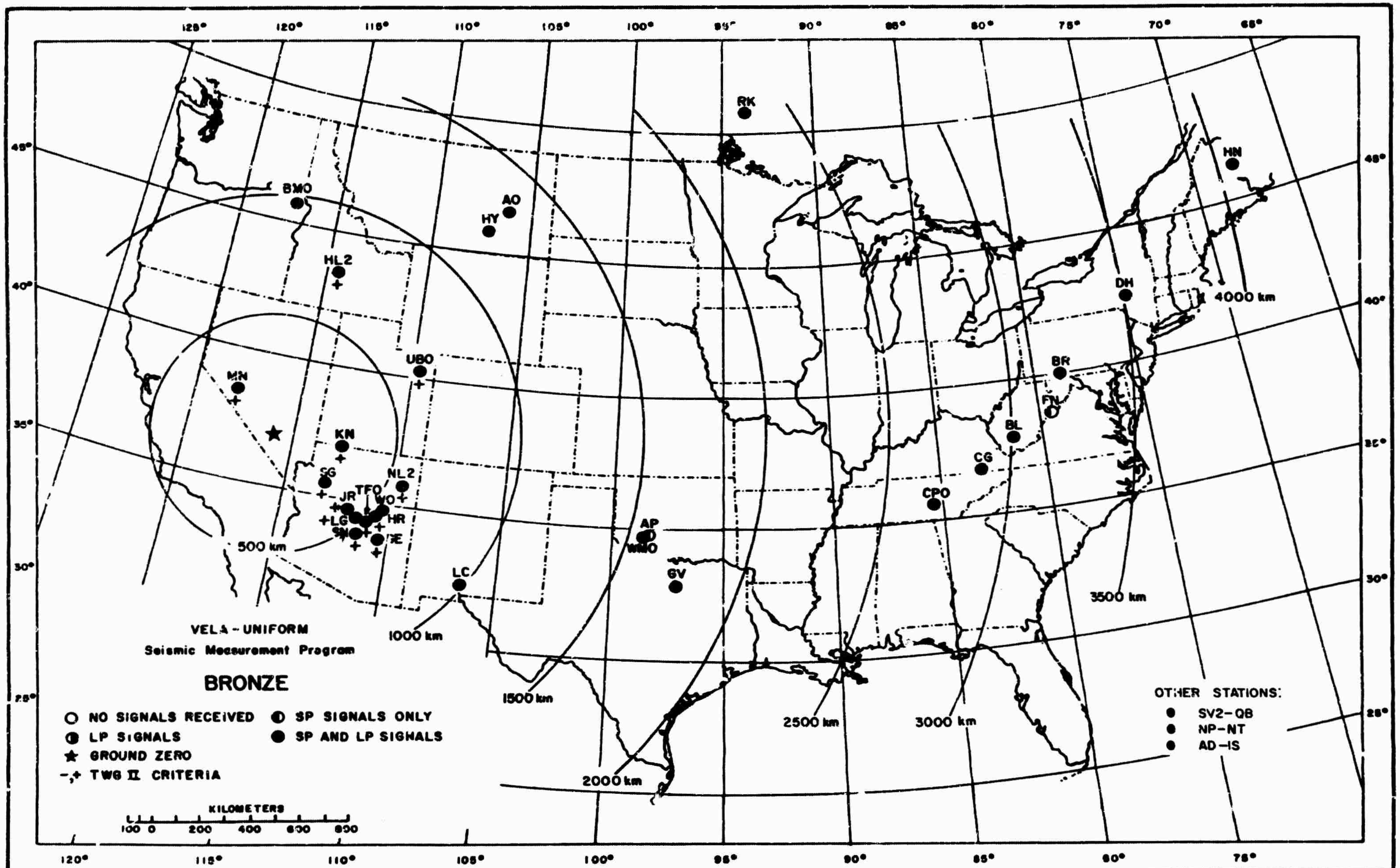
Time of Origin:	17:00:04.5Z
Depth:	50.4 km
Epicenter Shift:	14.0 km, S 43° W

Code	Station	Final							
		SPZ	SPR	SPT	LPZ	LPR	LPT	Tape	Timing
MN-NV	Mina, Nevada	+	+	+	+	+	+	*	P
KN-UT	Kanab, Utah	+	+	+	+	+	+	*	P
SG-AZ	Seligman, Arizona	+	+	+	+	+	+	*	P
JR-AZ	Jerome, Arizona	+	+	+	+	+	+	*	P
LG-AZ	Long Valley, Arizona	+	+	+	+	+	+	*	P
TFSO	Tonto Forest Observatory, Arizona	+	+	+	+	+	+	*	P
SN-AZ	Sunflower, Arizona	+	+	+	+	+	+	*	P
WO-AZ	Winslow, Arizona	+	+	+	+	+	+	*	P
HR-AZ	Heber, Arizona	+	+	+	+	+	+	*	P
NL2AZ	Nazlini, Arizona	+	+	+	+	+	+	*	P
GE-AZ	Globe, Arizona	+	+	+	+	+	+	*	P
UBSO	Uinta Basin Observatory, Utah	+	+	+	+	+	+	*	P
HL2ID	Hailey, Idaho	+	+	+	+	+	+	*	P
BMSO	Blue Mountain Observatory, Oregon	+	+	+	+	+	+	*	P
LC-NM	Las Cruces, New Mexico	+	+	+	+	+	+	*	P
HY-MA	Hysham, Montana	+	+	+	+	+	+	*	P
AO-MA	Subarray AØ, Montana	+	+	+	+	+	+	*	P
WMSO	Wichita Mountain Observatory, Oklahoma	+	+	+	+	+	+	*	P
AP-OK	Apache, Oklahoma	+	N	N	N	N	N	*	P
GV-TX	Grapevine, Texas	+	I	+	+	N	N	*	P
RK-ON	Red Lake, Ontario, Canada	+	+	+	+	+	+	*	P
CPSO	Cumberland Plateau Observatory, Tennessee	+	+	+	+	+	+	*	P
CG-VA	Cumberland Gap, Virginia	+	+	+	+	+	+	*	P
BL-WV	Beckley, West Virginia	+	+	+	+	+	+	*	P
FN-WV	Franklin, West Virginia	+	+	+	N	N	N	*	P
BR-PA	Berlin, Pennsylvania	+	+	+	+	+	+	*	P
DH-NY	Delhi, New York	+	+	+	+	+	+	*	P
HN-ME	Houlton, Maine	+	+	+	+	+	+	*	P
SV2QB	Schefferville, Quebec, Canada	+	N	N	+	I	I	*	P
NP-NT	Mould Bay, Northwest Territories, Canada	+	+	+	+	+	+	*	P
AD-IS	Adak Island, Alaska	+	+	+	+	-	-	*	P

I Inoperative
N No Instruments
P Primary Timing
+ Signal
- No Signal
* Magnetic Tape Available

Station Status Report - BRONZE

Table 1



Recording Stations and Signals Received

Figure 1

Introduction

A long range seismic measurements (LRSM) program was established under VELA-UNIFORM to record and analyze short-period and long-period data from a planned series of U. S. underground nuclear tests. These, and other data, will be used by VELA-UNIFORM participants for studying and developing methods for distinguishing between explosive and earthquake sources.

The purpose of this report is to provide an analysis of data resulting from the BRONZE event from the LRSM film seismograms from operating mobile field teams; Wichita Mountain Observatory, Oklahoma (WMSO), Uinta Basin Observatory, Utah (UBSO), Blue Mountain Observatory, Oregon (BMSO), Cumberland Plateau Observatory, Tennessee (CPSO), and Tonto Forest Observatory, Arizona (TFSO); and from several experimental or temporary stations operated in connection with other research programs.

Instrumentation and Procedure

Instrumentation at each of the mobile stations consists of three-component short-period Benioff and three-component Sprengnether long-period seismographs. Data are recorded on 35 millimeter film and on one-inch 14-channel

magnetic tape. All of these stations are equipped to record WWV continuously in order to provide accurate time control. Calibration is accomplished once each day and just prior to each shot at operating settings. Specific details of the instrumentation and operating procedures for these stations are given in Field Manual, Long Range Seismic Measurement Program, Technical Report No. 63-17, which can be obtained from the Geotech Division of Teledyne Industries, Inc., Dallas, Texas. All the observatories have both long-period and short-period, three-component instrumentation in addition to their other specialized facilities.

Station site information is presented in Appendix I(A). This includes the station name and code; the geographic coordinates, distances and azimuths involved; the station elevations; and the type of instruments in use at each location.

A status report for BRONZE is included in Table 1, placed opposite the operations map, Figure 1. This report gives the names of 31 stations and indicates which instruments were operational and which recorded usable signals.

An explanation of the procedure for amplitude measurements used in this report is illustrated in Appendix II. The unified magnitude (m) computations for distances less than

16° are based on AFTAC/VSC extensions of Gutenberg's Tables*. For this purpose, points from 10° to 16° were read from a curve in the Gutenberg-Richter paper and an inverse cube relationship was used to extrapolate from two to ten degrees. A table of the distance factors (B) is provided in Appendix I(B).

Appendix III quotes the Technical Working Group II (TWG II) first motion criteria, and includes diagrams illustrating the elements involved in determining a compression or rarefaction where satisfactory measurements can be made.

A standard hypocenter location program for a digital computer has been used to determine the location, using data from all stations analyzed. Best-fit values of latitude, longitude, depth of focus, and time of origin are determined statistically by a least squares technique. This utilizes a Jeffreys-Bullen travel-time curve as modified by Herrin in 1961 on the basis of Pacific surface focus recordings. Precision of the computation is limited primarily by the accuracy of arrival times, the validity of the standard travel-time curve, and by local velocity deviations. Since the method is based on P wave arrivals, this particular program does not

*Gutenberg, B. and Richter, C. F., Magnitude and Energy of Earthquakes, Ann. Geofis., 9 (1956), pp. 1-15.

make use of later phases such as pP and S in the determination of depth or location. Results are shown on the Event Description page.

Data and Results

Table 2 summarizes the measurements made of the principal phases from the BRONZE event. Included are the Pn and P arrival times, the maximum amplitudes (A/T) of Pn or P and Pg motion as seen on the short-period vertical instruments, and the maximum amplitudes (A/T) of the Lg phase as measured on the short-period horizontal tangential component. Long-period Love and Rayleigh wave motion are also tabulated in (A/T) form. Thirty-one stations recorded short-period signals. Long-period signals from this event were recorded by 29 stations.

In addition, Table 2 and Figure 2 show the unified magnitudes (m) where measurable. The average magnitude for BRONZE is 5.22. Twelve stations show compressional first motion as defined by the First Motion Criteria (TWG II).

The travel-time residuals from the Pn and P phase are within the usual limits (see Figure 3). The amplitudes of Pn and P, Pg and Lg are shown in Figures 4, 5 and 6. Lines proportional to the inverse cube of the distance visually fitted through the observed points are shown on these graphs.

Love and Rayleigh wave amplitudes are shown in Figures 7 and 8.

Attached to the report are illustrative seismograms showing the signals recorded at four locations. The most distant station analyzed that recorded BRONZE was AD-IS at a distance of 4939 kilometers.

Principal Phases
BRONZE
23 July 1965
17:00:00.0Z

Code	Station	Distance (km)	Inst.	Magnification (k) Film x 10	Phase	Observed Travel Time (min)	Observed Travel Time (sec)	Period T (sec)	Maximum Amplitude A/T	TWG II First Motion	Magnitude (m)
MN-NV	Mina, Nevada	238	SPZ	[illegible]	Pn	00	36.2	0.6	1105	C	5.31
			SPZ	1.7	e	00	38.0	0.6	1507		
			SPZ	[illegible]	Pg	00	39.1	0.5	7242		
			SPT	[illegible]	Lg			0.8	9041		
			LPT	81.6	LQ			(8.0)	(138)		
			LPZ	9.87	LR			14.0	554		
KN-UT	Kanab, Utah	285	SPZ	6.94	Pn	00	42.8	0.7	1693	C	5.71
			SPZ	2.44*	Pg	00	47.8	0.6	10,[illegible]		
			SPT	2.41*	Lg			0.8	13,267		
			LPT	[illegible]	LQ			14.0	[illegible]		
			LPZ	5.93	LR			14.0	651		
SG-AZ	Seligman, Arizona	297	SPZ	2.85	Pn	00	44.4	0.4	443	C	5.18
			SPZ	2.85	Pg	00	49.0	0.7	7823		
			SPT	5.65	Lg			0.7	6557		
			LPT	42.7	LQ			(12.0)	(115)		
			LPZ	9.23	LR			13.0	867		
JR-AZ	Jerome, Arizona	443	SPZ-7	10.3	Pn	01	02.8	0.55	236	C	5.47
			SPZ-7	10.3	e	01	05.0	0.8	758		
			SPZ-7	10.3	e	01	11.6	0.9	735		
			SPZ-7	10.3	Pg	01	14.6	---	---		
			SPT		Lg			---	---		
			LPT	24.4	LQ			10.0	124		
			LPZ	2.16	LR			14.0	447		
LG-AZ	Long Valley, Arizona	504	SPZ	13.95*	Pn	01	11.0	(0.6)	(125)	C	(5.35)
			SPZ	13.35*	Pg			---	---		
			SPT		Lg			---	---		
			LPT	38.2	LQ			8.0	303		
			LPZ	9.12	LR			12.0	912		
TFSO	Tonto Forest Observatory, Arizona	532	SPZ-1	37.5	Pn	01	14.5	0.6	34.6	C	5.08
			SPZ-1	37.5	e	01	18.3	0.4	30.0		
			SPZ-1	17.0*	Pg	01	(30.0)	0.8	1131		
			SPN	12.0*	Lg			1.1	1825		
			LPZ	3.0	LR			17.0	136		
SN-AZ	Sunflower, Arizona	533	SPZ	11.1	Pn	01	12.2	0.6	123	C	5.43
			SPZ	11.1	e	01	16.8	0.65	207		
			SPZ	11.1	e	01	24.8	0.6	292		
			SPZ	11.1	Pg	01	30.1	0.8	3591		
			SPT	21.3	Lg			0.8	1208		
			LPT	16.9	LQ			8.0	255		
			LPZ	2.7	LR			14.0	477		
WO-AZ	Winslow, Arizona	546	SPZ	22.4	Pn	01	16.1	0.4	42.2		4.99
			SPZ	22.4	e	01	20.9	0.5	81.0		
			SPZ		Pg	01	30.0	---	---		
			SPT		Lg			---	---		
			LPT	38.1	LQ			(10.0)	204		
			LPZ	3.88	LR			13.0	766		
HR-AZ	Heber, Arizona	546	SPZ	30.3	Pn	01	16.5	0.7	90.0	C	[illegible]
			SPZ	30.3	e	01	20.4	0.7	173		
			SPZ	30.3	Pg	01	30.8	---	---		
			SPT	13.2*	Lg			(1.0)	(2348		
			LPT	33.0	LQ			10.0	231		
			LPZ	2.83	LR			11.0	1148		
NL2AZ	Narlini, Arizona	592	SPZ	23.3	Pn	01	21.5	0.60	256	C	5.87
			SPZ		Pg	01	39.8	---	---		
			SPT	26.8	Lg			0.7	1919		
			LPT	25.3	LQ			11.5	267		
			LPZ	3.25	LR			12.0	901		
GE-AZ	Globe, Arizona	621	SPZ	24.8	Pn	01	25.6	0.45	54.4	C	5.26
			SPZ	24.8	e	01	30.0	0.6	117		
			SPZ	24.8	Pg	01	45.4	1.0	1956		
			SPT	26.7	Lg			0.95	710		
			LPT	25.3	LQ			12.0	73.5		
			LPZ	3.9	LR			[illegible]	936		
UBSO	Uinta Basin Observatory, Utah	666	SPZ-10	9.6	Pn	01	33.7	0.7	312	C	6.09
			SPZ-10	9.6	e	01	35.3	0.7	424		
			SPZ-10	9.6	Pg	01	52.5	0.65	827		
			SPN	9.2	Lg			(1.3)	(1748)		
			LPZ	1.8	LR			13.0	318		
HL2ID	Hailey, Idaho	731	SPZ	36.8	Pn	01	38.7	0.7	11.6	C	4.77
			SPZ	36.8	e	01	41.4	0.6	46.[illegible]		
			SPZ	36.8	e	01	43.5	0.6	99.7		
			SPZ	36.8	e	01	52.1	0.6	155		
			SPZ	36.8	Pg	02	03.6	0.6	858		
			SPT	38.8	Lg			0.8	469		
			LPT	39.1	LQ			12.0	168		
			LPZ	4.25	LR			13.0	248		
BMO	Blue Mountain Observatory, Oregon	868	SPZ-8	410	Pn	01	57.6	0.6	16.1		5.17
			Z3	26.0	e	02	00.5	0.8	18.5		
			Z3	26.0	Pg	02	25.5	1.1	352		
			SPE	24.5	Lg			1.1	395		
			LPE	10.0	LQ			16.0	49.0		
			LPZ	1.0	LR			16.0	134		
LC-NM	Las Cruces, New Mexico	1008	SPZ	117.5	Pn	02	(16.0)	(0.9)	(6.93)		(5.05)
			SPZ	117.5	e	02	17.2	1.0	18		
			SPZ	117.5	e	02	23.2	1.0	38.3		
			SPZ	117.5	e	02	33.6	0.8	25.0		
			SPZ	117.5	e	02	44.2	0.8	36.7		
			SPZ	117.5	Pg	02	49.0	(0.8)	(319)		
			SPT	122.0	Lg			1.3	438		
			LPT	89.1	LQ			14.0	(41.0)		
			LPZ	7.6	(LR)			14.0	(508)		

Principal Phases
BRONZE
23 July 1965
17:00:00.0Z

Code	Station	Distance (km)	Inst	Magnification (k) Film x 10	Phase	Observed Travel Time (min)	Observed Travel Time (sec)	Period T (sec)	Maximum Amplitude A/T	TWO II First Motion	Magnitude (m)
HY-MA	Hysham Montana	1136	SPE	72.3	P	02	40.5	0.7	13.0		5.30
			SPZ	72.3	e	02	42.4	0.7	26.1		
			SPZ	72.3	e	02	43.8	0.7	21.3		
			SPZ	72.3	Pg	02	54.9	0.6	73.2		
			LPT	33.8	LQ			14.0	71.9		
			LPZ	9[illegible].5	LR			(13.0)	(154)		
AO-MA	Subarray A0, Montana	1339	SPZ	138.9	P	02	54.2	0.7	7.4		4.97
			SPZ	138.9	e	02	56.6	0.65	27.5		
			SPZ		Pg			---	---		
			SPT		Lg			---	---		
			LPT	20.7	LQ			14.0	(43.2)		
			LPE	4.11	LR			12.0	207		
WMSO	Wichita Mountain	1594	SPZ-6	210.0	P	03	26.9	0.9	43.3		5.15
	Observatory, Oklahoma		SPZ-6	210.0	e	03	34.8	0.9	42.1		
			SPZ-6	210.0	Pg	04	20.7	1.0	(23.8)		
			SPN								
			LPN	46.0	LQ			15.0	57.8		
			LPE	2.9	LR			15.0	96.6		
AP-OK	Apache, Oklahoma	1605	SPZ	471.0	P	03	28.3	0.9	87.4		5.40
			SPE	471.0	e	03	49.2	0.9	31.2		
			SPZ	471.0	Pg	04	30.5	1.2	129		
GV-TX	G[illegible]evine, Texas	1796	SPZ	25.55	P	03	(50.0)	(1.2)	(59.6)		(4.68)
			SPE	25.95	e	03	54.2	1.0	13.7		
			SPZ	25.95	Pg	05	08.0	(1.1)	(158)		
			SPT	20.6	Lg			(1.6)	([illegible])		
			LPZ	23.95	LR			13.0	227		
RK-ON	Red Lake, Ontario,	2341	SPZ	203.0	P	04	45.6	1.0	237		5.40
	Canada		SPZ	203.0	e	04	50.5	1.0	145		
			SPZ	203.0	PP	05	10.0	0.8	49.7		
			SPT	202.0	Lg			1.3	52.9		
			LPE	23.0	LR			13.0	61.6		
CPSO	Cumberland Plateau	2728	SPZ-8	420.0	P	05	21.7	0.85	45.1		5.05
	Observatory, Tennessee		SPZ-8	420.0	e	05	27.9	0.85	28.9		
			LPZ	15.0	LR			15.0	84.0		
CG-VA	Cumberland Gap, Virginia	2909	SPZ	423.0	P	05	37.1	1.0	54.3		5.15
			SPZ	423.0	e	05	(53.8)	0.8	24.5		
			SPT	399.0	Lg			1.6	71.5		
			LPT	7.70	LQ			(12.0)	(53.1)		
			LPE	17.4	LR			13.0	160		
BL-WV	Beckley, West Virginia	3056	SPZ	125.6	P	05	48.2	0.8	29.0		5.02
			SPZ	125.6	e	05	56.0	0.7	20.5		
			SPZ	125.6	e	06	23.6	0.8	24.0		
			SPZ	125.6	PcP	09	08.0	0.7	17.0		
			SPT	132.6	Lg			(2.0)	(138)		
			LPT	15.25	LQ			(17.0)	(18.2)		
			LPZ	19.0	LR			17.0	52.0		
FM-WV	Franklin, West Virginia	3199	SPZ	169.0	P	06	00.0	0.8	12.4		4.69
			SPZ	169.0	e	06	25.2	1.0	25.0		
			SPZ	169.0	e	06	55.5	0.8	16.0		
			SPT	182.0	Lg			2.0	72.0		
BE-PA	Berlin, Pennsylvania	3236	SPZ	105.9	P	06	03.0	0.8	31.2		5.09
			SPZ	105.9	e	06	09.5	0.7	19.4		
			SPZ	105.5	e	06	16.9	0.8	20.8		
			SPE	105.9	e	06	21.3	1.1	57.7		
			SPZ	105.9	PcP	09	12.3	0.9	12.9		
			SPT	154.0	Lg			2.0	102		
			LPT	23.95	LQ			16.0	20.4		
			LPZ	18.82	LR			14.0	147		
DH-NY	Delhi, New York	3542	SPE	231.0	P	06	26.7	0.6	22.9		5.16
			SPZ	231.0	e	06	(29.9)	0.6	24.0		
			SPZ	231.0	e	06	31.9	0.6	22.0		
			SPZ	231.0	PcP	09	18.0	0.65	16.9		
			SPT	227.0	Lg			(2.0)	(16.9)		
			LPT	25.5	LQ			16.0	29.0		
			LPZ	25.7	LR			13.0	178		
HN-ME	Houlton, Maine	4034	SPZ	122.8	P	07	07.9	0.7	20.2		4.85
			SPZ	122.8	e	07	09.3	0.7	54.5		
			SPZ	122.8	PcP	09	32.3	0.75	9.2		
			SPT	116.5	Lg			2.0	33.7		
			LPT	14.7	LQ			15.0	26.6		
			LPE	29.2	LR			16.0	41.9		
SV3QB	Schefferville, Quebec,	4187	SPZ-3	107.5	P	07	16.3	0.8	35.9		5.09
	Canada		SPZ-3	107.5	e	07	20.9	0.7	26.0		
			LPE	52.4	LR			13.0	55.0		
MP-NT	Mould Bay, Northwest	4360	SPZ	164.0	P	07	30.8	0.8	50.5		5.11
	Territories, Canada		SPZ	164.0	e	07	32.2	0.75	94.9		
			SPZ	164.0	e	07	39.0	0.8	32.2		
			SPE	164.0	PP	09	00.0	1.2	16.3		
			SPZ	164.0	PcP	09	39.8	0.8	19.0		
			SPT	171.9	PcS	11	28.4	1.3	11.5		
			SPT	171.9	(Lg)	20	(05)	(2.3)	(36.4)		
			LPT	4.92	LQ			17.0	18.8		
			LPZ	4.26	e			28.0	4.7		
			LPE	4.26	LR			17.0	50.0		
AD-IS	Adak Island, Alaska	4939	SPZ	33.0	P	08	12.0	0.7	70.0		5.44
			SPZ	33.0	e	08	13.1	0.7	93.5		
			SPZ	33.0	e	08	15.7	0.8	41.7		
			LPZ	[illegible]	Oceanic "R"			27.0	4.2		

A/T mu/sec
( ) Doubtful Values Made From Playouts
* Measurements Made From Playouts
e Phases Reported But Not Identified
--- Signal not Measurable because of Excessive Amplitude or Amplitude Clipping on Film or Playout

Principal Phases - BRONZE

Table 2 - Page 2

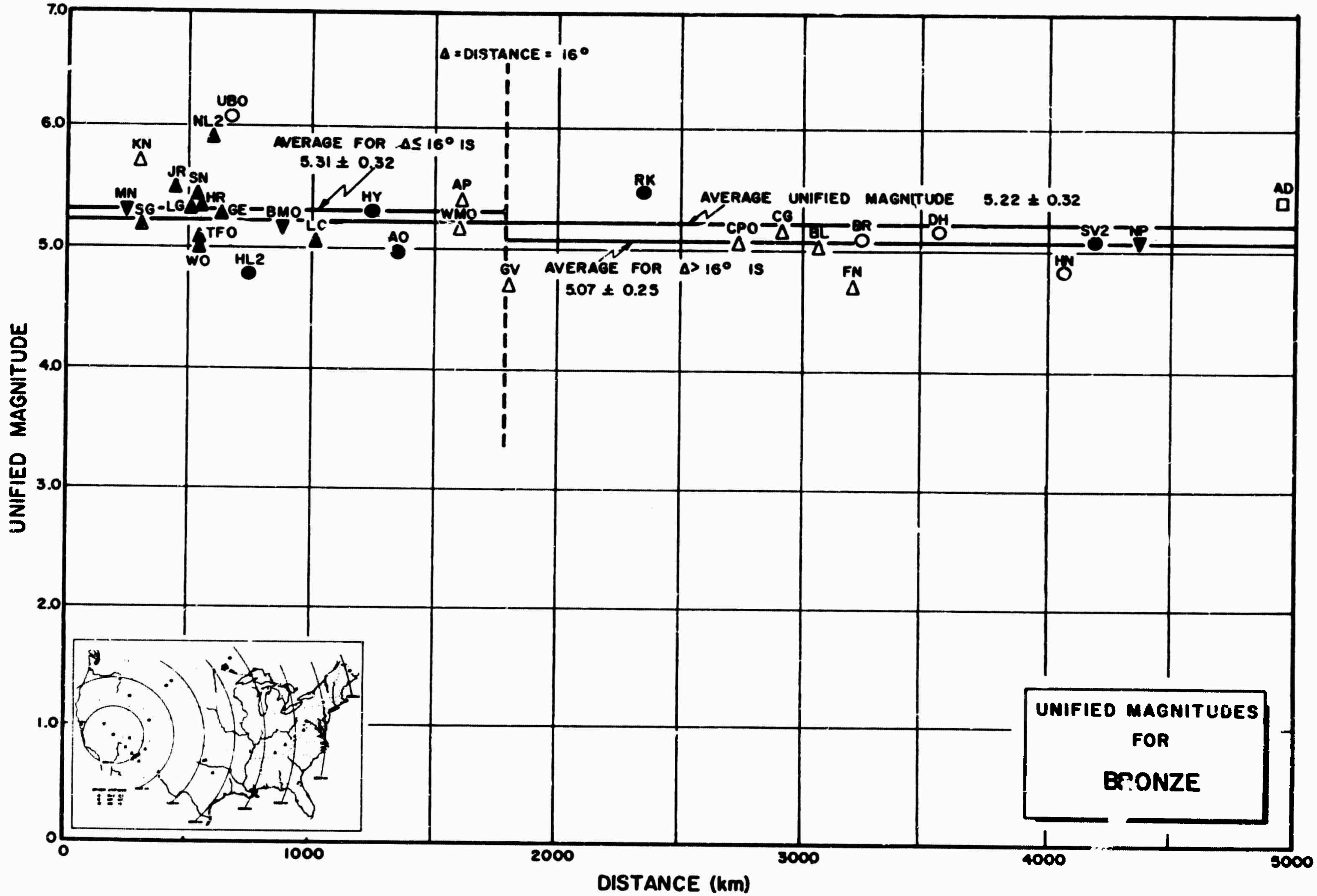

UNIFIED MAGNITUDES
FOR
BRONZE
Δ = DISTANCE = 16°
AVERAGE FOR Δ≤ 16° IS
5.31 ± 0.32
AVERAGE FOR Δ> 16° IS
5.07 ± 0.25
AVERAGE UNIFIED MAGNITUDE 5.22 ± 0.32
UBO
NL2
KN
JR
SN
MN
SG
LG
HR
GE
BMO
LC
HY
AO
TFO
WO
HL2
AP
WMO
GV
RK
CPO
CG
BL
BR
FN
DH
HN
SV2
NP
AD
UNIFIED MAGNITUDE
DISTANCE (km)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
0
1000
2000
3000
4000
5000

Figure 2

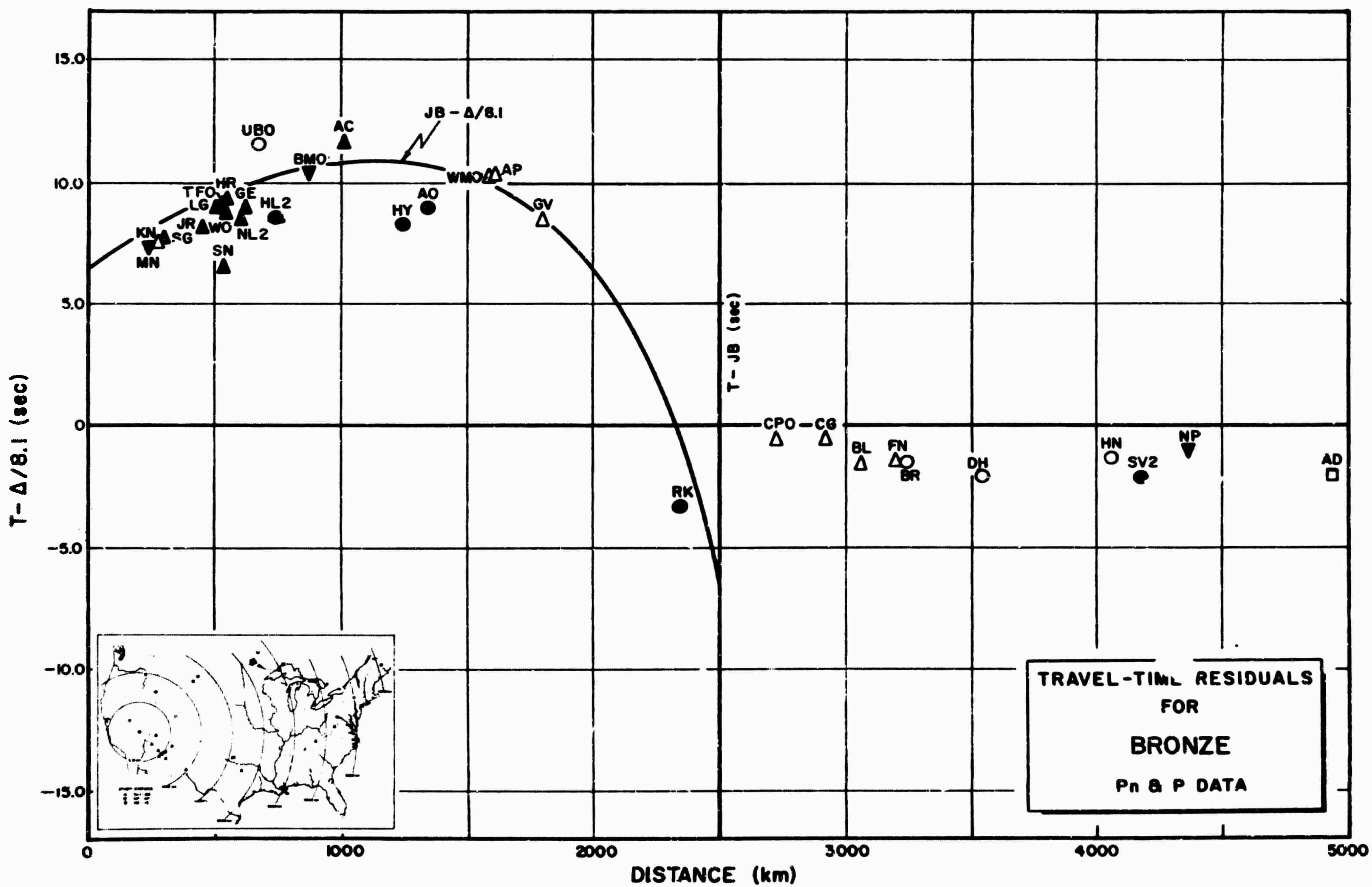
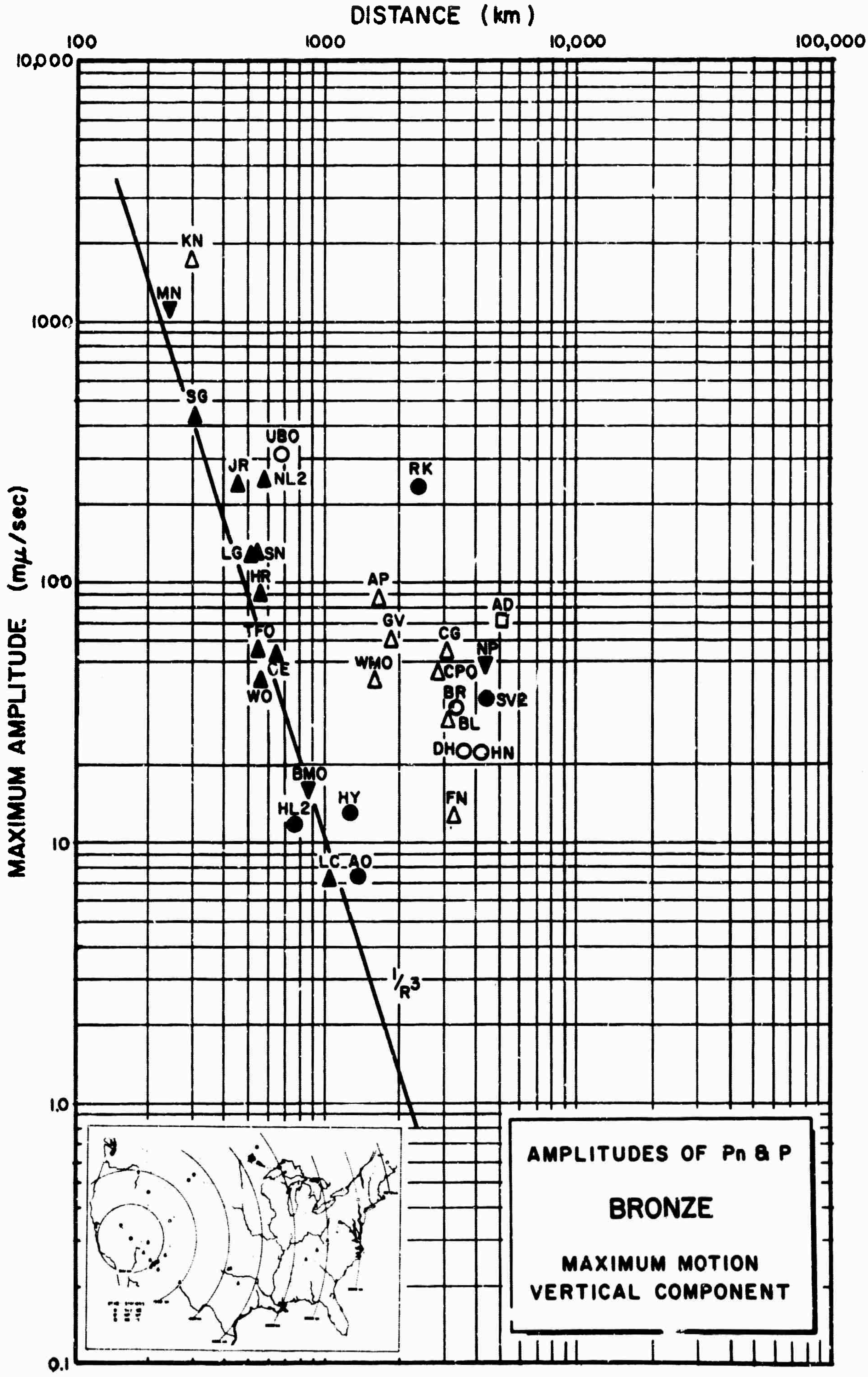

TRAVEL-TIME RESIDUALS
FOR
BRONZE
Pn & P DATA
T- Δ/8.1 (sec)
DISTANCE (km)
T - JB (sec)
JB - Δ/8.1
15.0
10.0
5.0
0
-5.0
-10.0
-15.0
0
1000
2000
3000
4000
5000
UBO
AC
BMO
HR
TFO
GE
LG
HL2
JR
WO
NL2
KN
SG
MN
SN
HY
AO
WMO
AP
GV
RK
CPO
CG
BL
FN
BR
DH
HN
SV2
NP
AD

Figure 3



DISTANCE (km)
100
1000
10,000
100,000
10,000
1000
100
10
1.0
0.1
MAXIMUM AMPLITUDE (mμ/sec)
KN
MN
SG
UBO
JR
NL2
RK
LG
SN
HR
AP
AD
GV
TFO
CG
NP
CE
WMO
CPO
WO
BR
SV2
BL
DH
HN
BMO
HY
FN
HL2
LC
AO
1/R3
AMPLITUDES OF Pn & P
BRONZE
MAXIMUM MOTION
VERTICAL COMPONENT

Figure 4

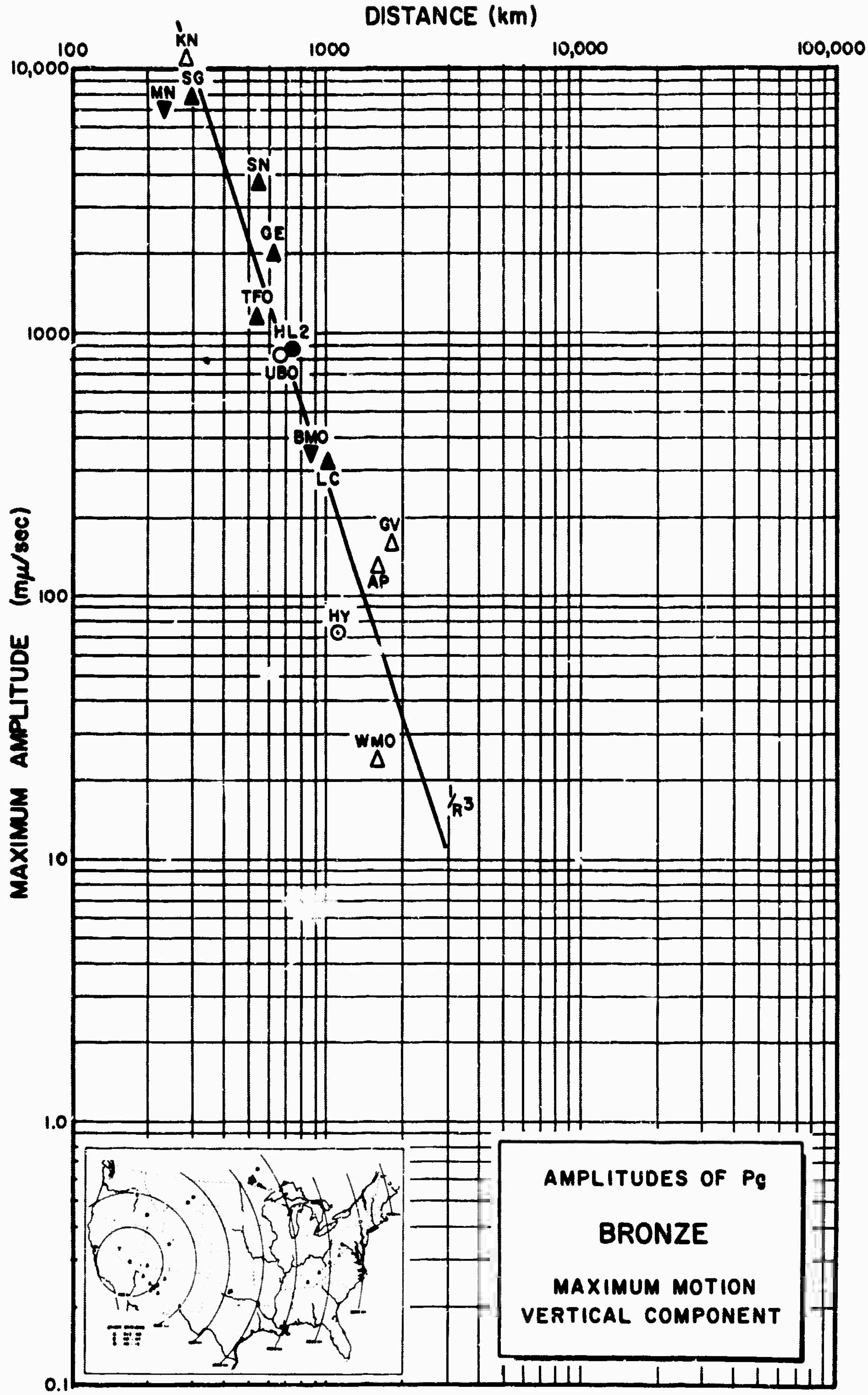
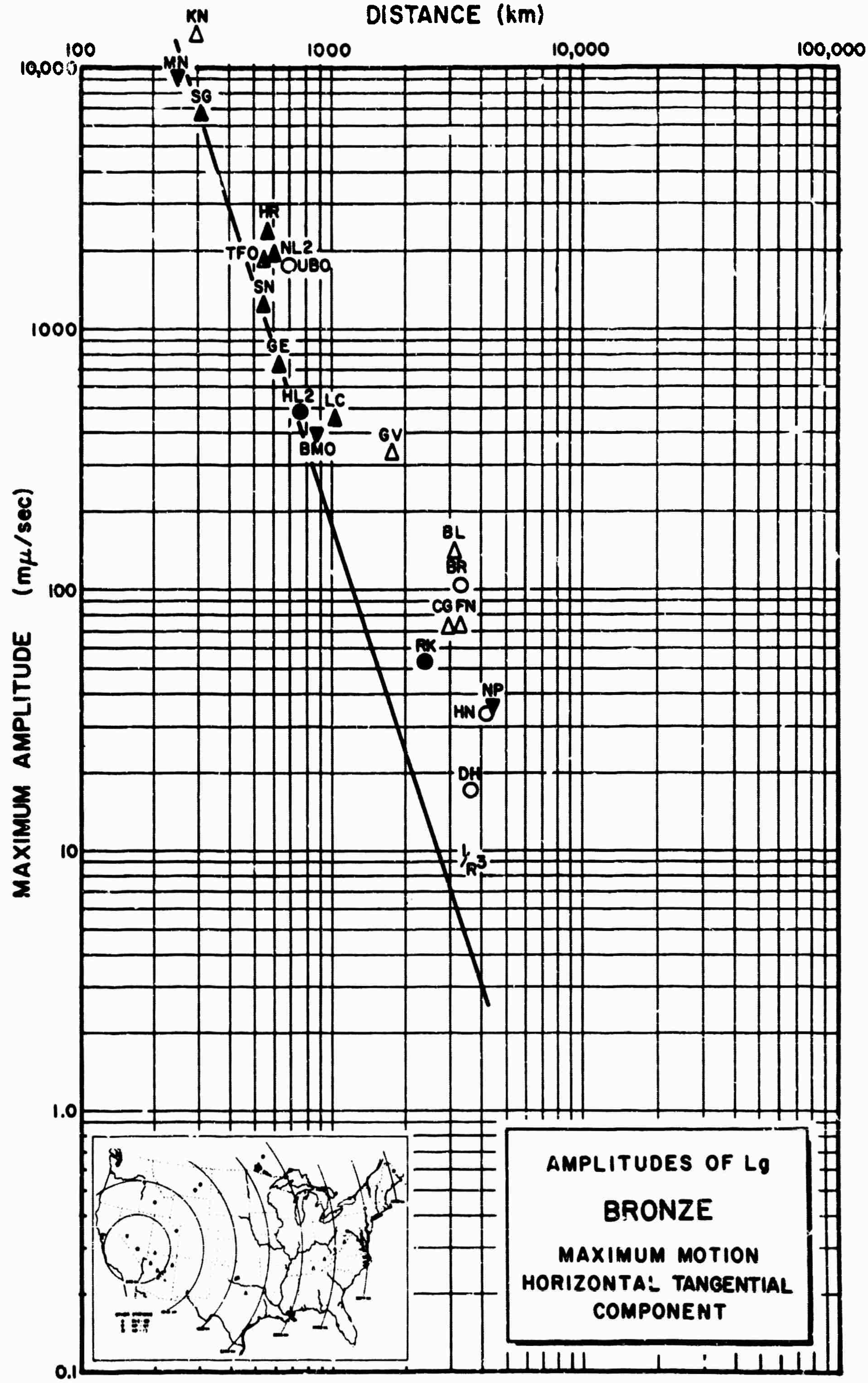

DISTANCE (km)
100
1000
10,000
100,000
10,000
1000
100
10
1.0
0.1
MAXIMUM AMPLITUDE (mμ/sec)
KN
SG
MN
SN
GE
TFO
HL2
UBO
BMO
LC
GV
AP
HY
WMO
1/R3
AMPLITUDES OF Pg
BRONZE
MAXIMUM MOTION
VERTICAL COMPONENT

Figure 5



DISTANCE (km)
100
1000
10,000
100,000
MAXIMUM AMPLITUDE (mμ/sec)
10,000
1000
100
10
1.0
0.1
KN
MN
SG
HR
TFO
NL2
UBO
SN
GE
HL2
LC
BMO
GV
BL
BR
CG
FN
RK
NP
HN
DH
1/R3
AMPLITUDES OF Lg
BRONZE
MAXIMUM MOTION
HORIZONTAL TANGENTIAL
COMPONENT

Figure 6

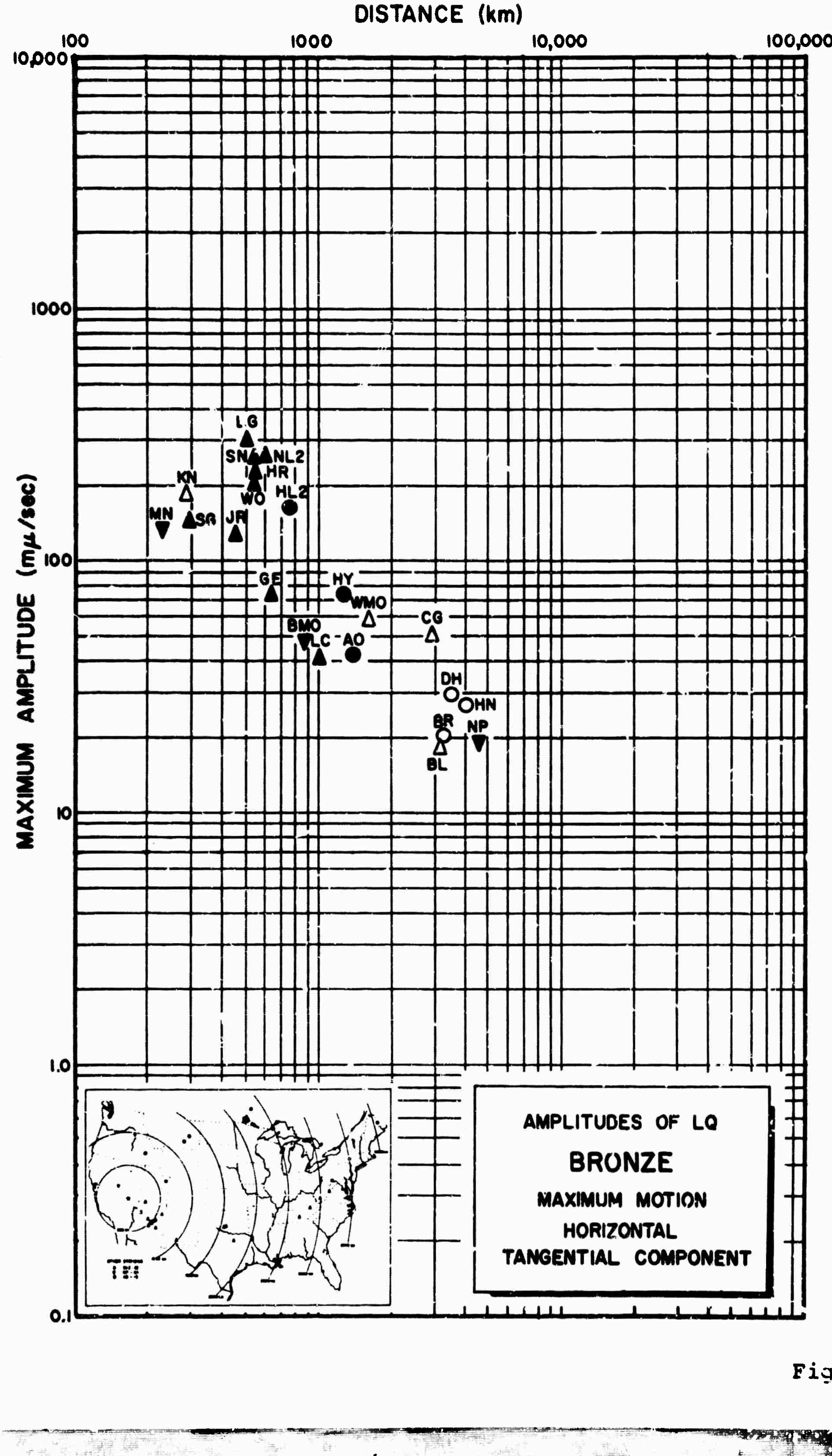
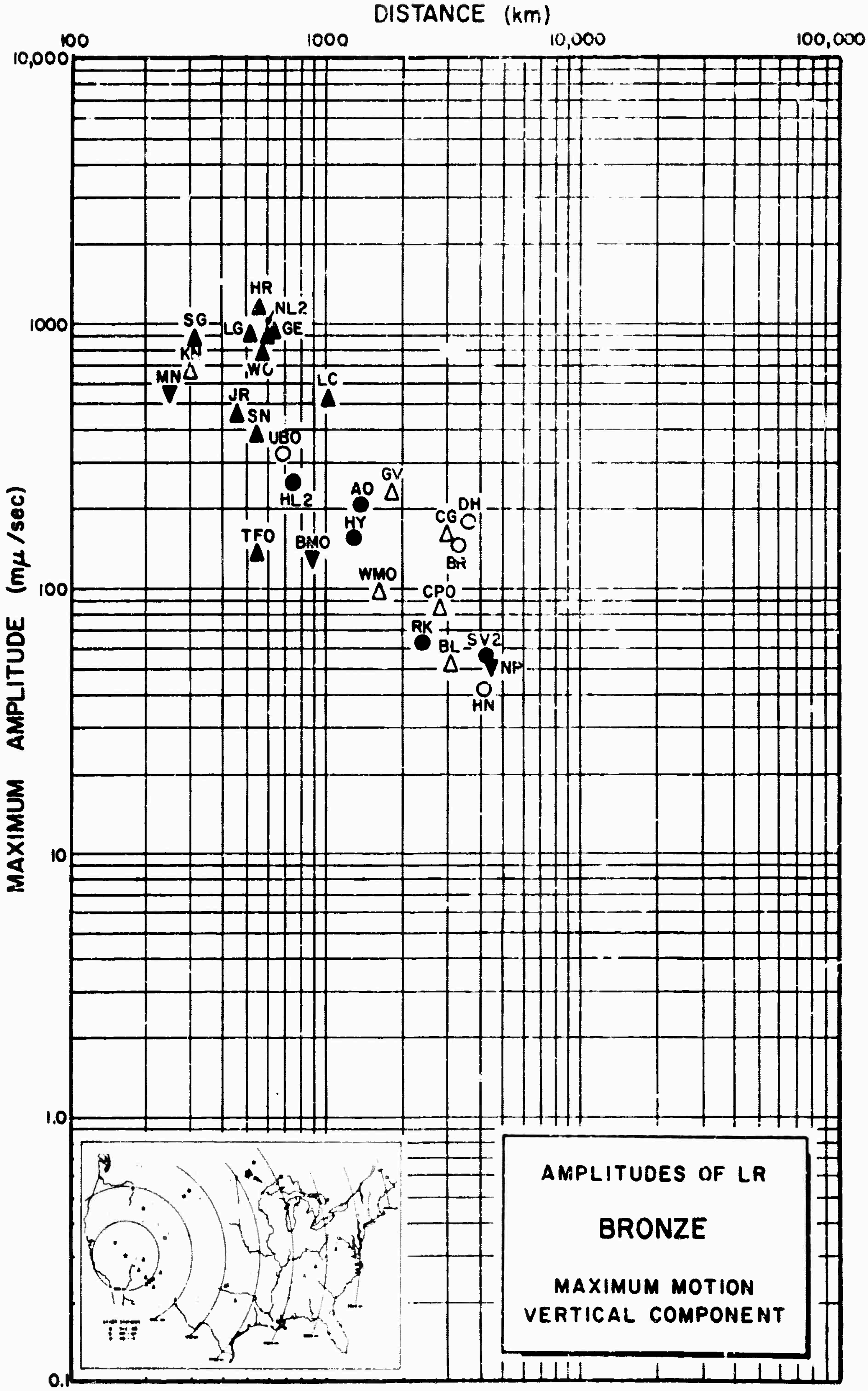

DISTANCE (km)
100
1000
10,000
100,000
10,000
1000
100
10
1.0
0.1
MAXIMUM AMPLITUDE (mμ/sec)
LG
SN
NL2
HR
KN
WO
HL2
MN
SG
JR
GE
HY
WMO
CG
BMO
LC
AO
DH
HN
BR
NP
BL
AMPLITUDES OF LQ
BRONZE
MAXIMUM MOTION
HORIZONTAL
TANGENTIAL COMPONENT

Figure 7



DISTANCE (km)
100
1000
10,000
100,000
10,000
1000
100
10
1.0
0.1
MAXIMUM AMPLITUDE (mμ /sec)
HR
NL2
SG
LG
GE
KN
WC
MN
LC
JR
SN
UBO
GV
HL2
AO
DH
HY
CG
TFO
BMO
BR
WMO
CPO
RK
SV2
BL
NP
HN
AMPLITUDES OF LR
BRONZE
MAXIMUM MOTION
VERTICAL COMPONENT

Figure 8

Code	Station	Distance (km)	Geographic Latitude	Geographic Longitude	Elev. (km)	Computed Azimuth		Installed Azimuth		Large or Small SP	LP Inst.
						Epi. Sta.	Sta. Epi.	Radial	Tang.		
MN-NV	Mina, Nevada	238	38°26'10" N	118°08'33" W	1.524	309°	128°	308°	38°	L	X
KN-UT	Kanab, Utah	285	37°01'22" N	112°49'39" W	1.737	91°	273°	95°	185°	L	X
SG-AZ	Seligman, Arizona	297	35°38'27" N	113°15'39" W	1.680	122°	304°	131°	221°	L	X
JR-AZ	Jerome, Arizona	443	34°49'32" N	111°59'25" W	1.310	123°	306°	131°	221°	L	X
LG-AZ	Long Valley, Arizona	504	34°24'28" N	111°32'45" W	1.770	125°	308°	131°	221°	S	X
TFSO	Tonto Forest Observatory, Arizona	532	34°17'32" N	111°16'03" W	1.609	124°	307°	90°	0°	JM	X
SN-AZ	Sunflower, Arizona	533	33°51'49" N	111°41'34" W	0.880	131°	314°	131°	221°	L	X
WO-AZ	Winslow, Arizona	546	34°52'53" N	110°37'15" W	1.590	115°	298°	131°	221°	L	X
HR-AZ	Heber, Arizona	546	34°40'11" N	110°45'59" W	1.875	118°	301°	131°	221°	L	X
NL2AZ	Nazlini, Arizona	592	35°48'25" N	109°37'43" W	1.920	102°	286°	131°	221°	S	X
GE-AZ	Globe, Arizona	621	33°46'32" N	110°31'41" W	1.480	125°	308°	131°	221°	L	X
UBSO	Uinta Basin Observatory, Utah	666	40°19'18" N	109°34'07" W	1.475	56°	240°	90°	0°	JM	X
HL2ID	Hailey, Idaho	731	44°33'40" N	114°25'08" W	1.830	10°	191°	13°	103°	L	X
BMSO	Blue Mountain Observatory, Oregon	868	44°50'56" N	117°18'20" W	1.139	353°	172°	0°	90°	JM	X
LC-NM	Las Cruces, New Mexico	1008	32°24'08" N	106°35'58" W	1.585	118°	304°	124°	214°	L	X
HY-MA	Hysham, Montana	1236	45°58'21" N	107°0[illegible]'45" W	0.976	34°	220°	41°	131°	L	X
AO-MA	Subarray AØ, Montana	1339	46°41'19" N	106°13'20" W	0.892	34°	221°	42°	132°	S	X
WMSO	Wichita Mountain Observatory, Oklahoma	1594	34°43'05" N	98°35'21" W	0.505	94°	285°	90°	0°	JM	X
AP-OK	Apache, Oklahoma	1605	34°49'59" N	98°26'09" W	0.427	94°	284°			S	
GV-TX	Grapevine, Texas	1796	32°53'09" N	96°59'54" W	0.152	99°	290°	111°	201°	L	LPZ
RK-ON	Red Lake, Ontario, Canada	2341	50°50'20" N	93°40'20" W	0.366	42°	238°	58°	148°	S	X
CPSO	Cumberland Plateau Observatory, Tennessee	2728	35°35'41" N	85°34'13" W	0.574	84°	283°	90°	0°	JM	X
CG-VA	Cumberland Gap, Virginia	2909	36°37'35" N	83°15'36" W	0.396	81°	261°	101°	191°	L	X
BL-WV	Beckley, West Virginia	3056	37°47'56" N	81°18'36" W	0.610	78°	279°	100°	190°	S	X
FN-WV	Franklin, West Virginia	3199	38°32'58" N	79°30'47" W	0.910	76°	279°	99°	169°	S	
BR-PA	Berlin, Pennsylvania	3236	39°55'27" N	78°50'41" W	0.064	73°	276°	97°	187°	L	X
DH-NY	Delhi, New York	3542	42°14'39" N	74°53'18" W	0.652	68°	275°	95°	185°	S	X
HN-ME	Houlton, Maine	4064	46°09'43" N	67°59'09" W	0.210	60°	273°	93°	183°	S	X
SV2OB	Schefferville, Quebec, Canada	4187	54°48'54" N	66°45'31" W	0.594	46°	263°	131°	221°	S	LPZ
MP-NT	Mould Bay, Northwest Territories, Canada	4368	76°15'08" N	119°22'18" W	0.059	359°	176°	356°	86°	JMZ S	X
AD-IS	Adak Island, Alaska	4939	51°52'30" N	176°40'45" W	0.061	309°	85°	0°	90°	L	X

Recording Site Information - BRONZE

Appendix I(A)

Unified Magnitude: $m = \log_{10} (A/T)_{\prime} + B$

where A = zero to peak ground motion in millimicrons $= \dfrac{(mm)\ (1000)}{K}$

T = signal period in seconds

B = distance factor (see Table below)

mm = record amplitude in millimeters zero to peak

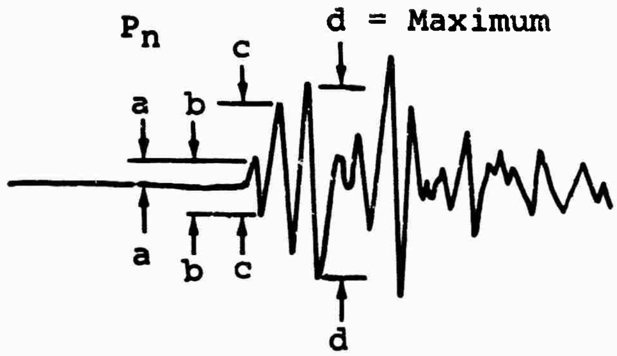
K = magnification in thousands at signal frequency

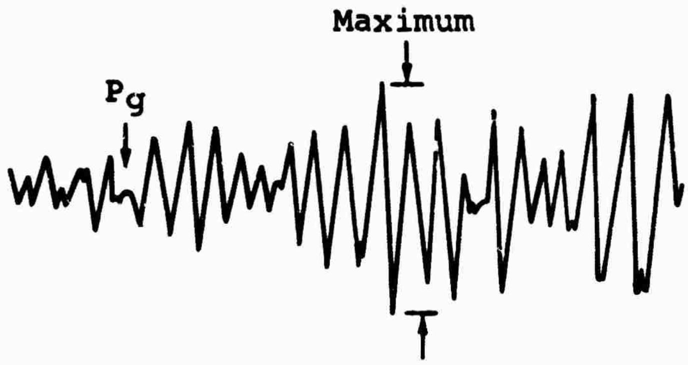
Table of Distance Factors (B) for Zero Depth

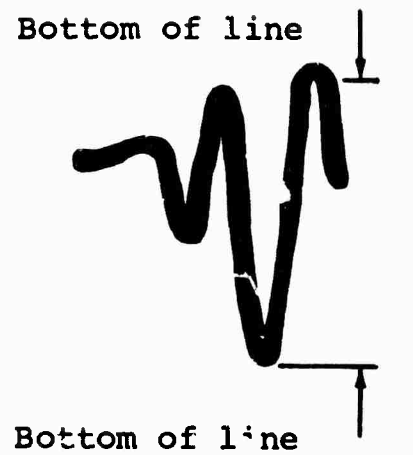
Dist (deg)	B	Dist (deg)	B	Dist (deg)	B	Dist (deg)	B
0°	-	27°	3.5	54°	3.8	80°	3.7
1	-	28	3.6	55	3.8	81	3.8
2	2.2	29	3.6	56	3.8	82	3.9
3	2.7	30	3.6	57	3.8	83	4.0
4	3.1	31	3.7	58	3.8	84	4.0
5	3.4	32	3.7	59	3.8	85	4.0
6	3.6	33	3.7	60	3.8	86	3.9
7	3.8	34	3.7	61	3.9	87	4.0
8	4.0	35	3.7	62	4.0	88	4.1
9	4.2	36	3.6	63	3.9	89	4.0
10	4.3	37	3.5	64	4.0	90	4.0
11	4.2	38	3.5	65	4.0	91	4.1
12	4.1	39	3.4	66	4.0	92	4.1
13	4.0	40	3.4	67	4.0	93	4.2
14	3.6	41	3.5	68	4.0	94	4.1
15	3.3	42	3.5	69	4.0	95	4.2
16	2.9	43	3.5	70	3.9	96	4.3
17	2.9	44	3.5	71	3.9	97	4.4
18	2.9	45	3.7	72	3.9	98	4.5
19	3.0	46	3.8	73	3.9	99	4.5
20	3.0	47	3.9	74	3.8	100	4.4
21	3.1	48	3.9	75	3.8	101	4.3
22	3.2	49	3.8	76	3.9	102	4.4
23	3.3	50	3.7	77	3.9	103	4.5
24	3.3	51	3.7	78	3.9	104	4.6
25	3.5	52	3.7	79	3.8	105	4.7
26	3.4	53	3.7				

Unified Magnitudes From P_n or P Waves

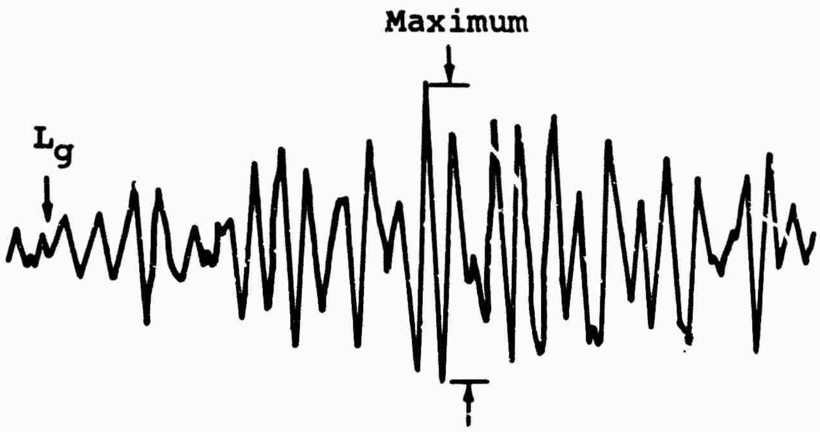
Appendix I(B)







Detail Showing Allowance For Line Width



Pick <u>time</u> of <u>Pn</u> at beginning of "a" half cycle.

Pick <u>amplitude</u> of <u>Pn</u> as maximum "$d/_2$" within 2 or 3 cycles of "c".

Pick <u>amplitudes</u> of <u>Pg</u> and <u>Lg</u> at maximum of corresponding motion.

Seismic Analysis Diagram

Appendix II

FIRST MOTION CRITERIA
TECHNICAL WORKING GROUP II (TWG II)

Excerpt from Appendices to Hearings before the Special Subcommittee on Radiation and the Subcommittee on Research and Development of the Joint Committee on Atomic Energy; 86th Cong., 2d Sess.; April 19-22, 1960; on Technical Aspects of Detection and Inspection Controls of a Nuclear Weapons Test Ban; Part 2 of 2 Parts, pp 632-633:

"2. Identification of Earthquakes

A located seismic event shall be ineligible for inspection if, and only if, it fulfills one or more of the following criteria:

a. Its depth of focus is established as below 60 kilometers;

b. Its epicentral location is established to be in the deep open ocean and the event is unaccompanied by a hydroacoustic signal consistent with the seismic epicenter and origin time;

c. It is established within 48 hours to be a foreshock by the occurrence of a larger event of at least magnitude 6 whose epicenter coincides with that of the given event within the accuracy of the determination of the two epicenters. The eligibility of the second event for inspection must be determined separately.

d. The directions of clearly recorded first motions define a pattern which strongly indicates a faulting source. First motions recorded at distances between 1100 kilometers and 2500 kilometers will not be used. First motions beyond 3500 kilometers will not be used for events of magnitude smaller than 5.5. The apparent direction of first motion must also meet both the following minimum conditions to be considered to be clearly recorded:

(1) The amplitude of the half-cycle of apparent first motion is at least two (2) times as large as any half-cycle of apparent noise in the preceding few minutes, and

(2) The largest of the amplitudes of the half-cycle of apparent first motion and the two immediately following half-cycles:

(a) at epicentral distances less than 700 kilometers is twenty (20) times larger than any half-cycle of noise in the preceding few minutes;

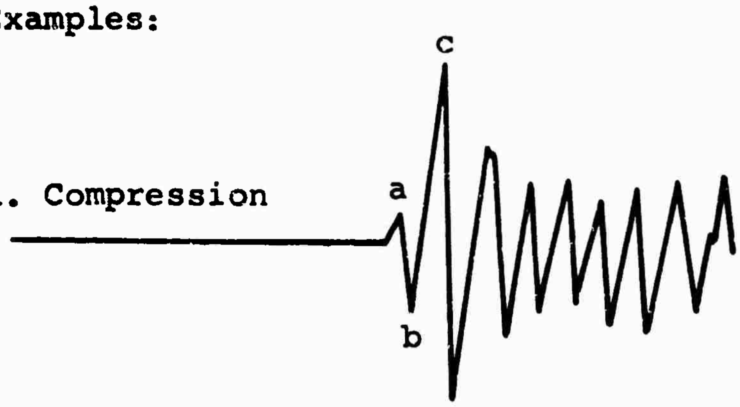
(b) at epicentral distances more than 700 kilometers is forty (40) times larger than any half-cycle of noise in the preceding few minutes.

A pattern of clearly recorded first motions strongly indicates a faulting source if the observed motions, extended backward to a small sphere about the focus, can be separated into alternate quadrants by two orthogonal great circles drawn on the small sphere, with the requirement that two opposite quadrants combined (i) contain at least 4 clearly recorded rarefactive first motions and (ii) contain not more than 15% compressions among the clearly recorded first motions."

Application of the TWG II Criteria

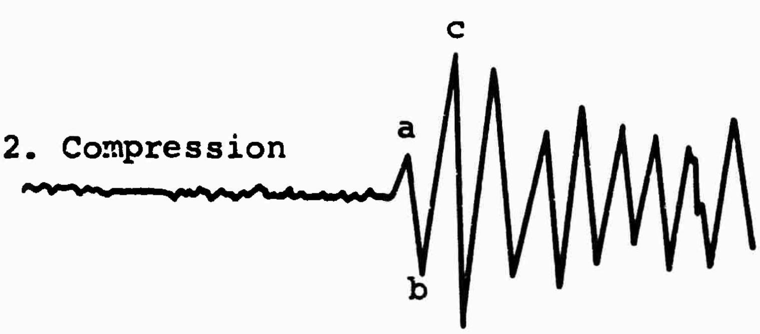
Examples:

1. Compression



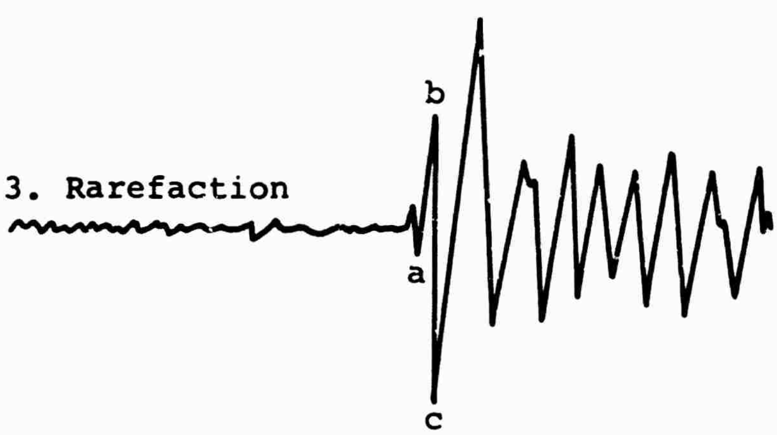
$700 < \Delta < 1100$ Km

2. Compression



$\Delta < 700$ Km

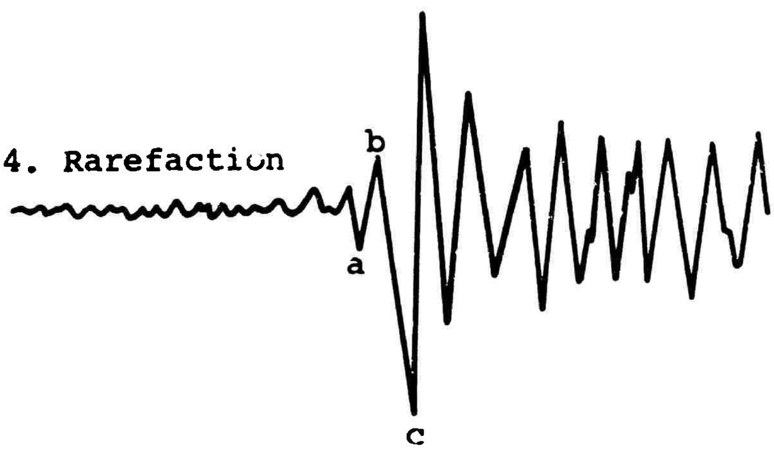
3. Rarefaction



$\Delta < 700$ Km. Example shows what may be interpreted to be earlier signal; however, motion is less than 2 times the noise level and may be interpreted as noise.

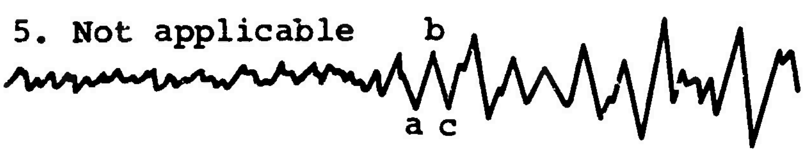
Application of the TWG II Criteria

4. Rarefaction

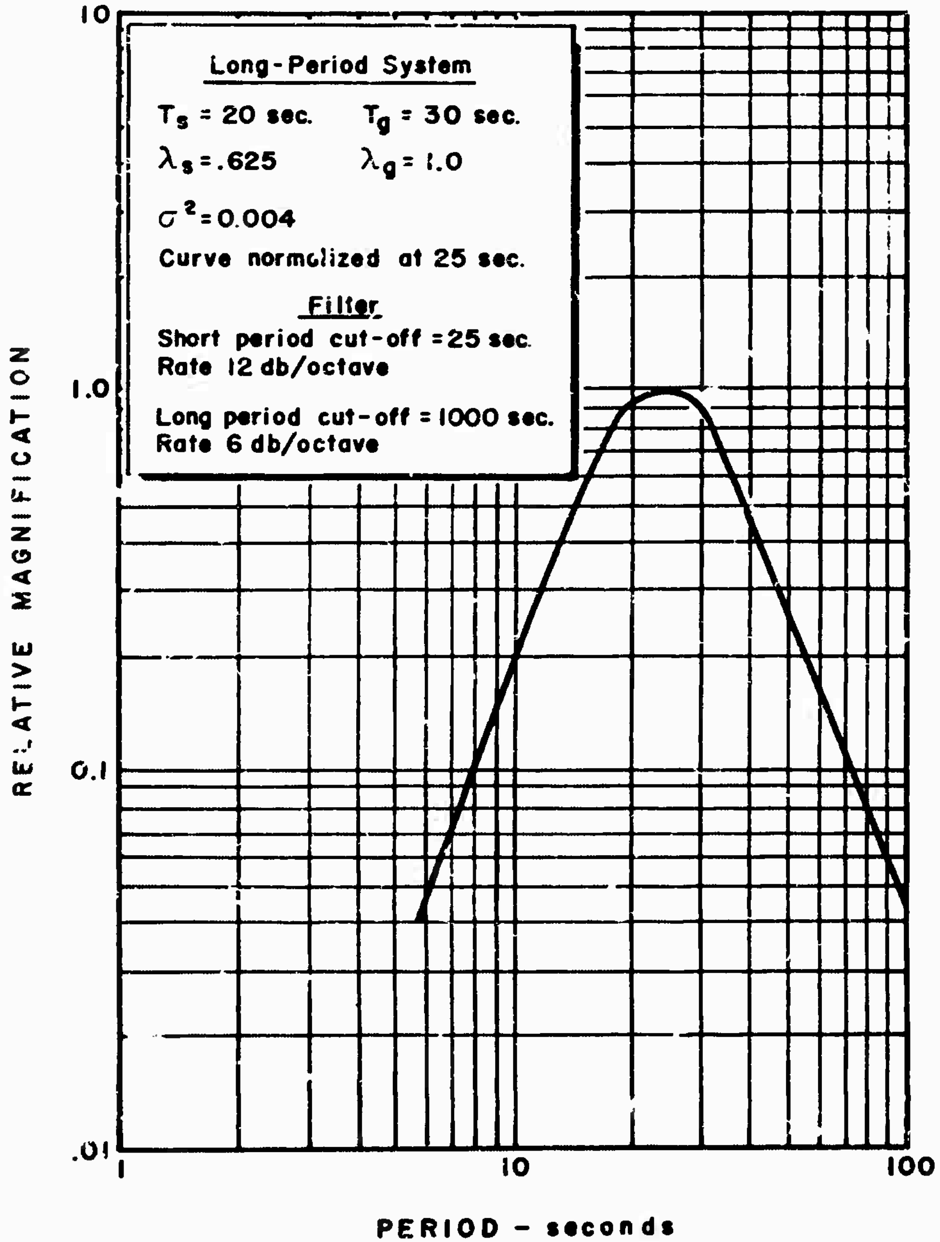


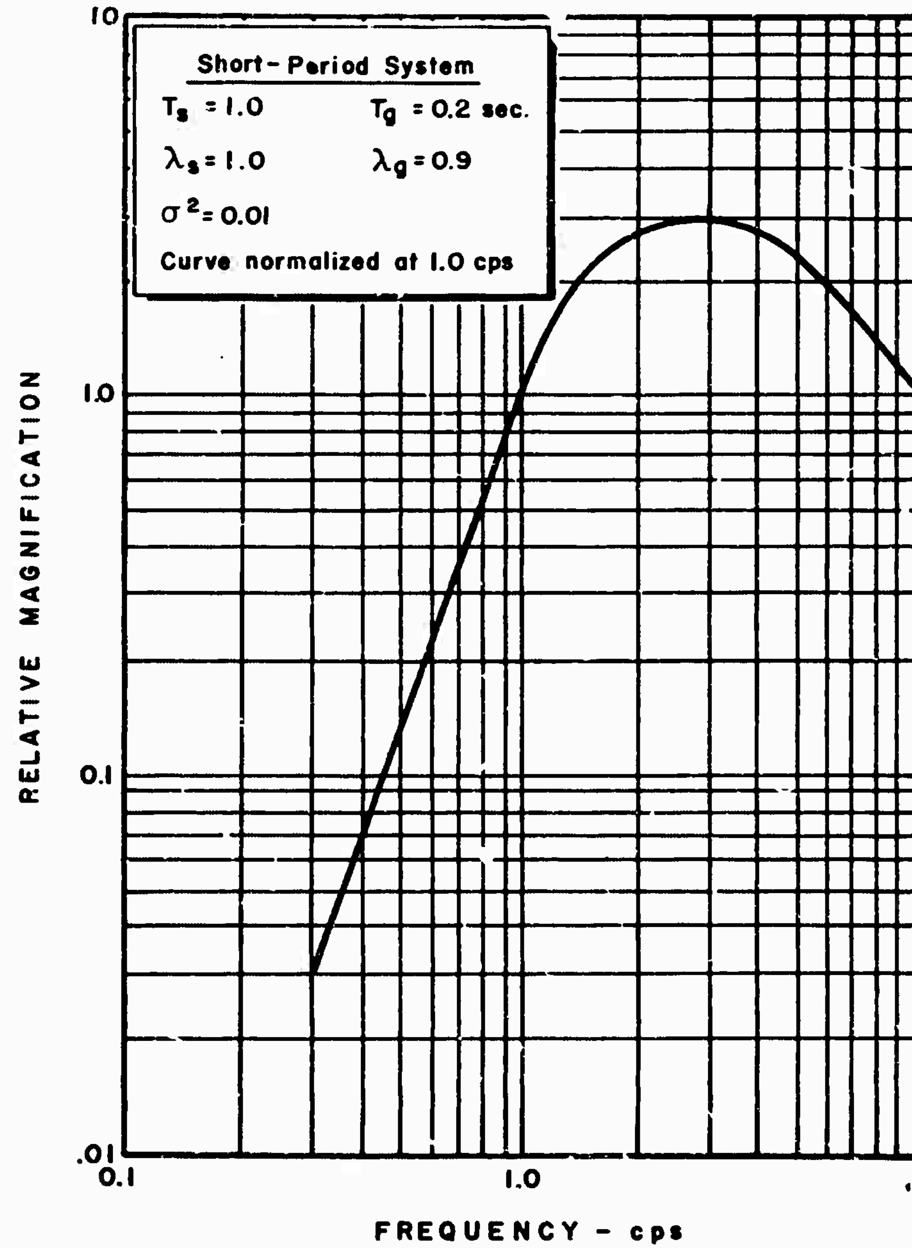
$\Delta < 700$ Km
Similar to Example 3.

5. Not applicable



$\Delta < 700$ Km
Amplitude of first
3 half-cycles is less
than 20 times noise.





LP and SP Response Curves

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3. REPORT TITLE

Long Range Seismic Measurements - BRONZE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Scientific Report

5. AUTHOR(S) (Last name, first name, initial)

Clark, Don M.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
3 December 1965	21	1

8a. CONTRACT OR GRANT NO. AF 33(657)-12447 b. PROJECT NO. VELA T/2037 c. ARPA Order No. 624 d. ARPA Program Code No. 5810	9a. ORIGINATOR'S REPORT NUMBER(S) SDL Report No. 132 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) --

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13. ABSTRACT

An analysis of seismological data from an underground nuclear explosion as a continuing study to provide information to aid in distinguishing between earthquakes and explosions. A table of travel-times and amplitudes of P, Pg, Lg, and surface waves are included along with other unidentified phases.

DD FORM 1 JAN 64 1473

Unclassified
Security Classification

Unclassified

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Seismic Magnitude						
Seismic Travel-Time						
Seismic Amplitude						
VELA-UNIFORM						
Nuclear Tests						

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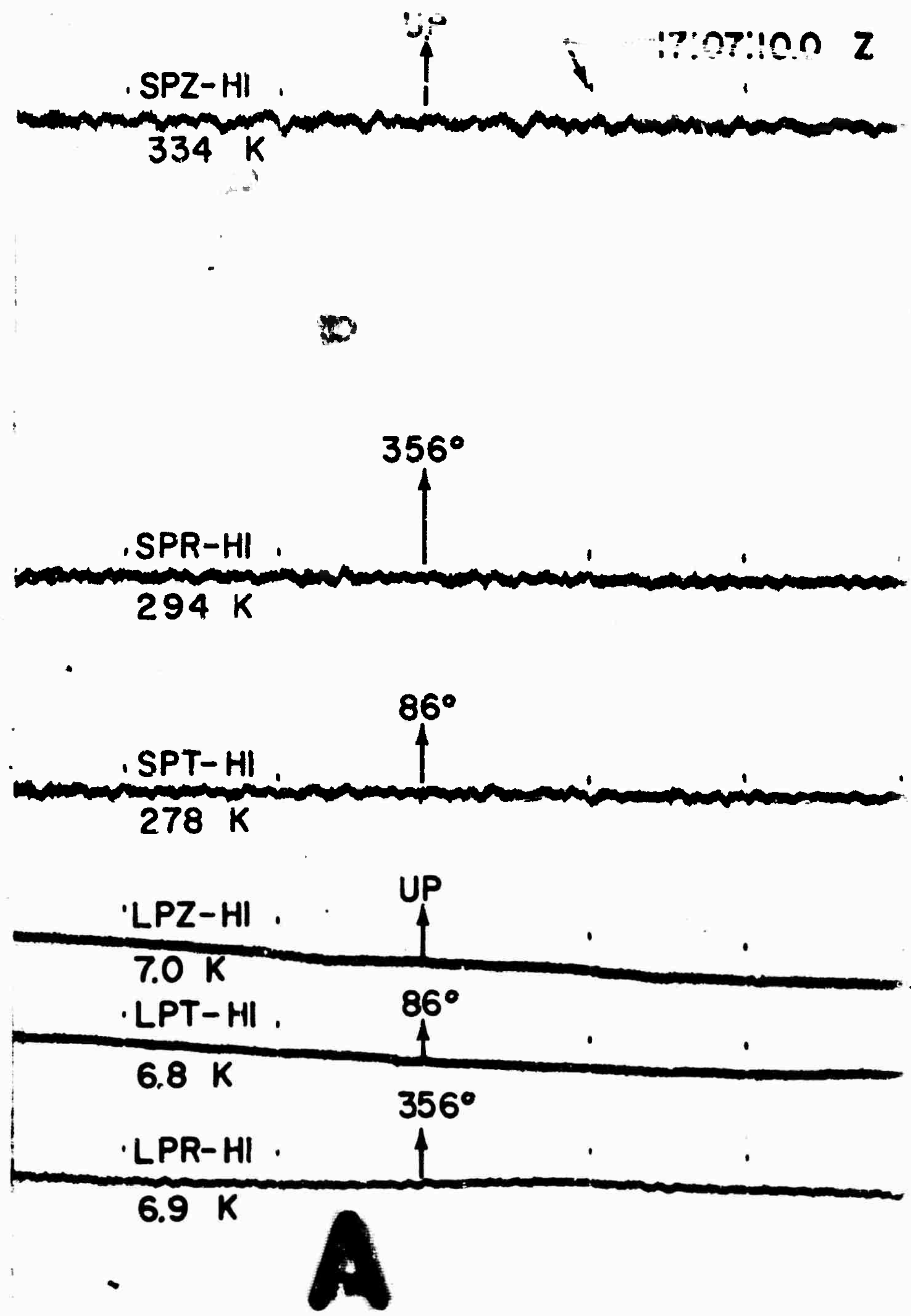
BRONZE

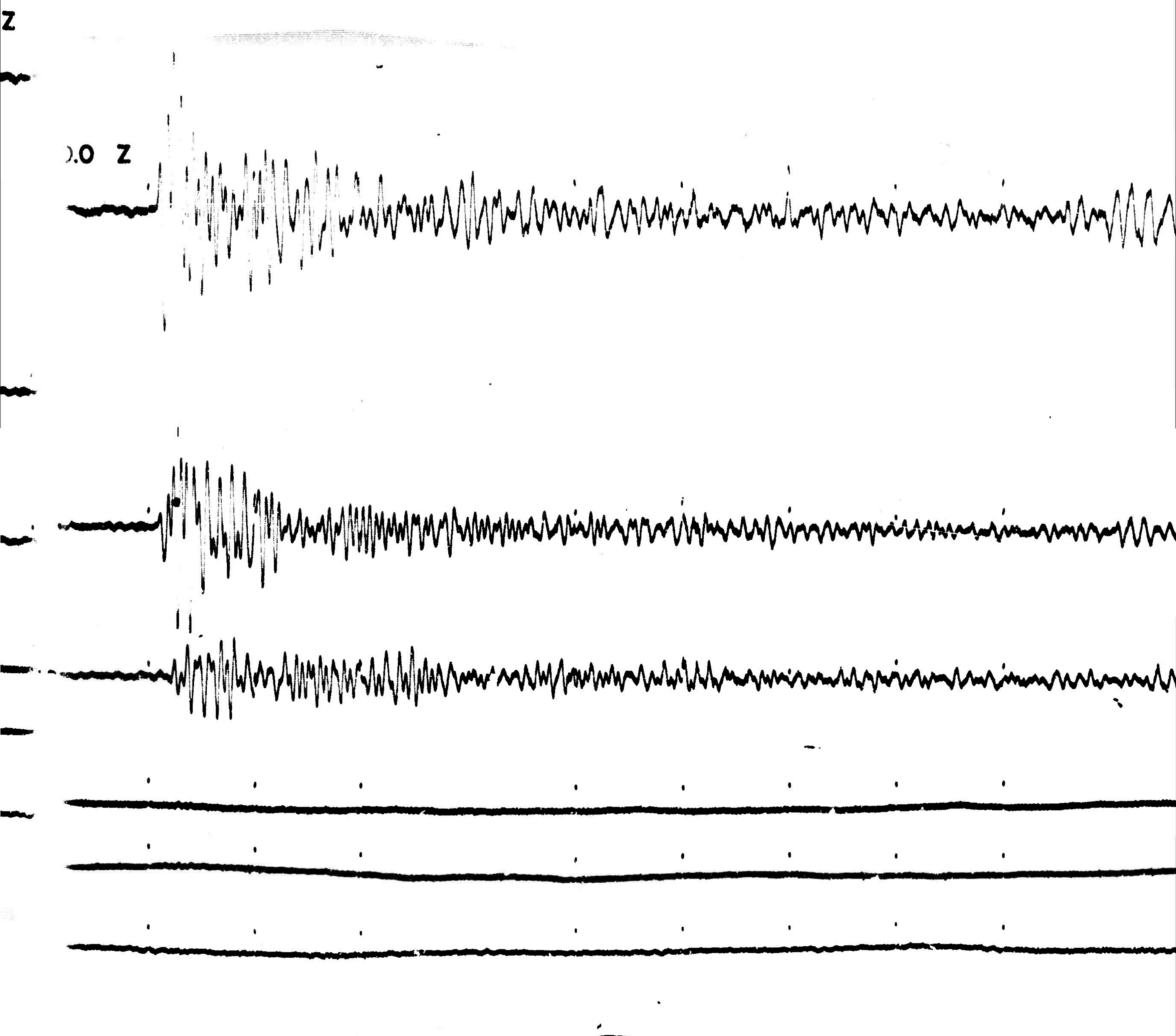
NP-NT

Mould Bay, Northwest Territories

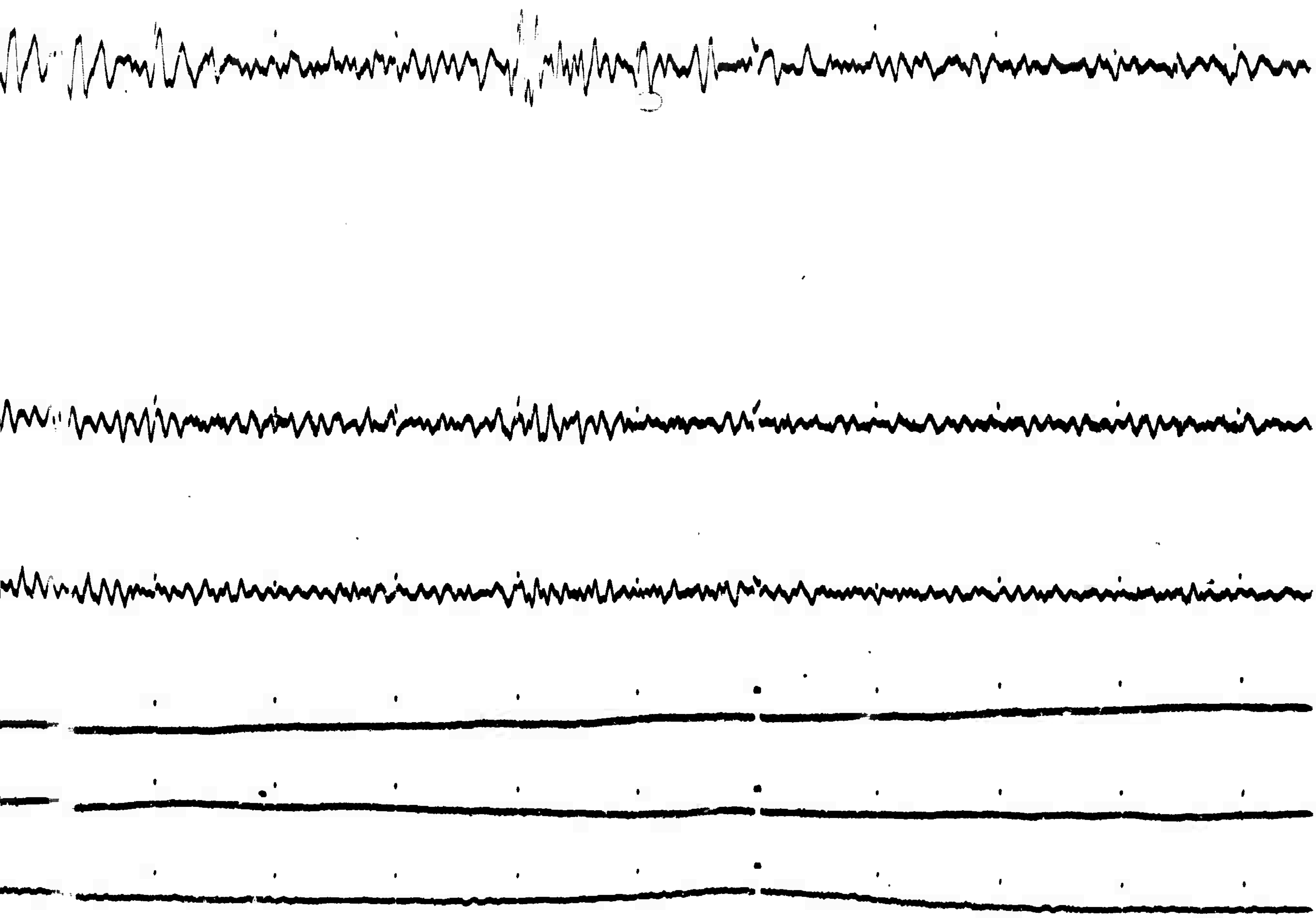
23 July 1965

Δ = 4364 km

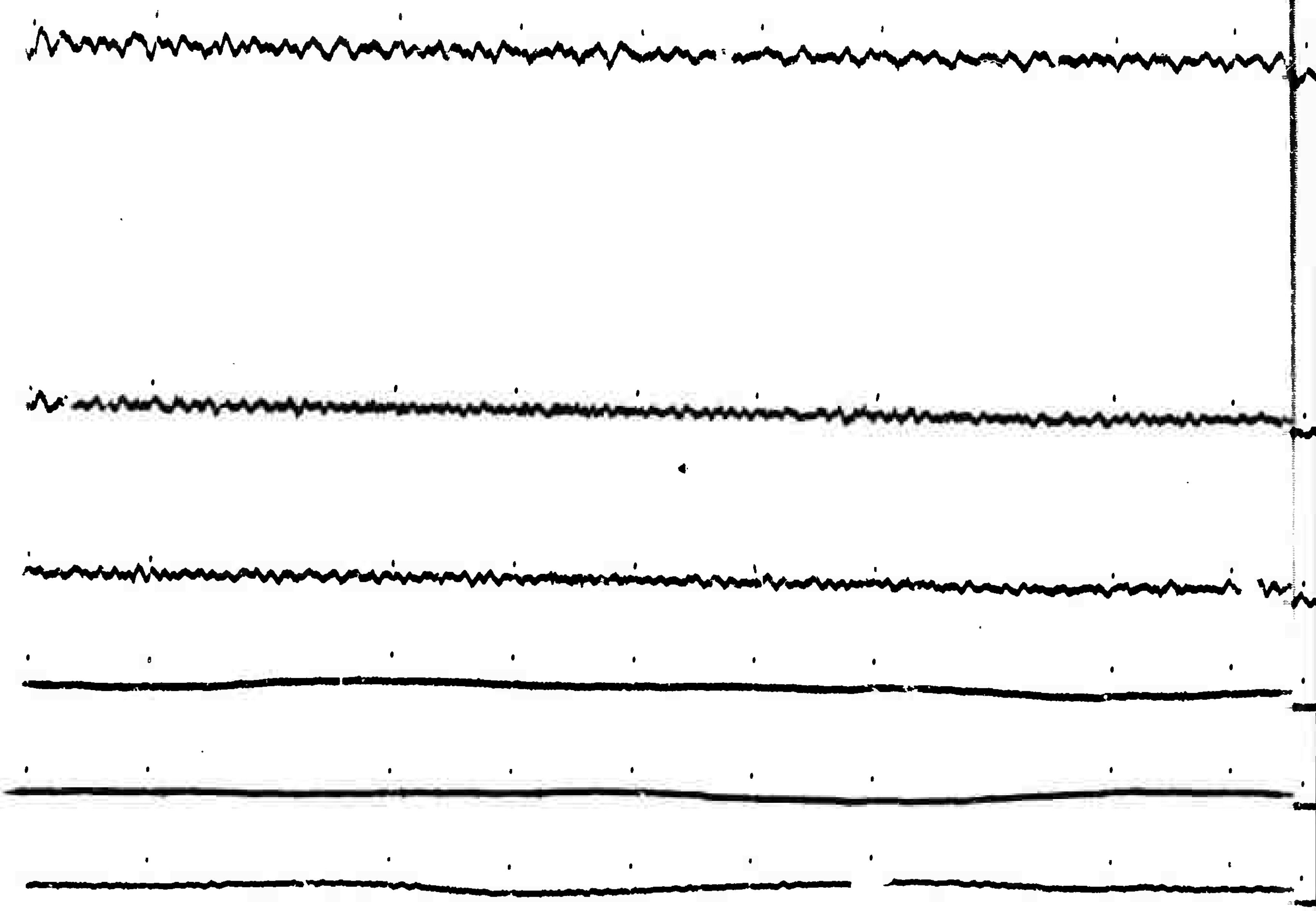




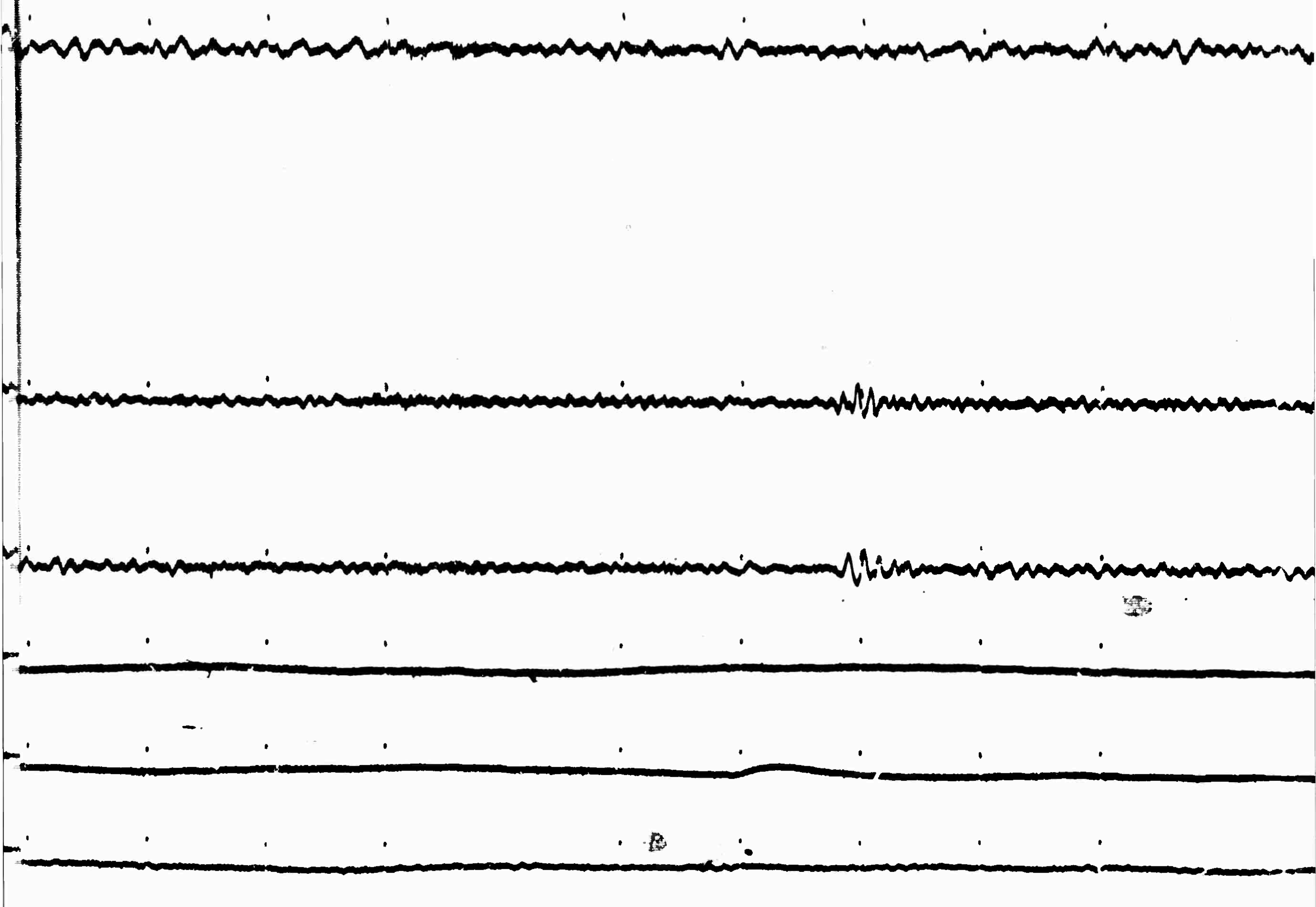
B



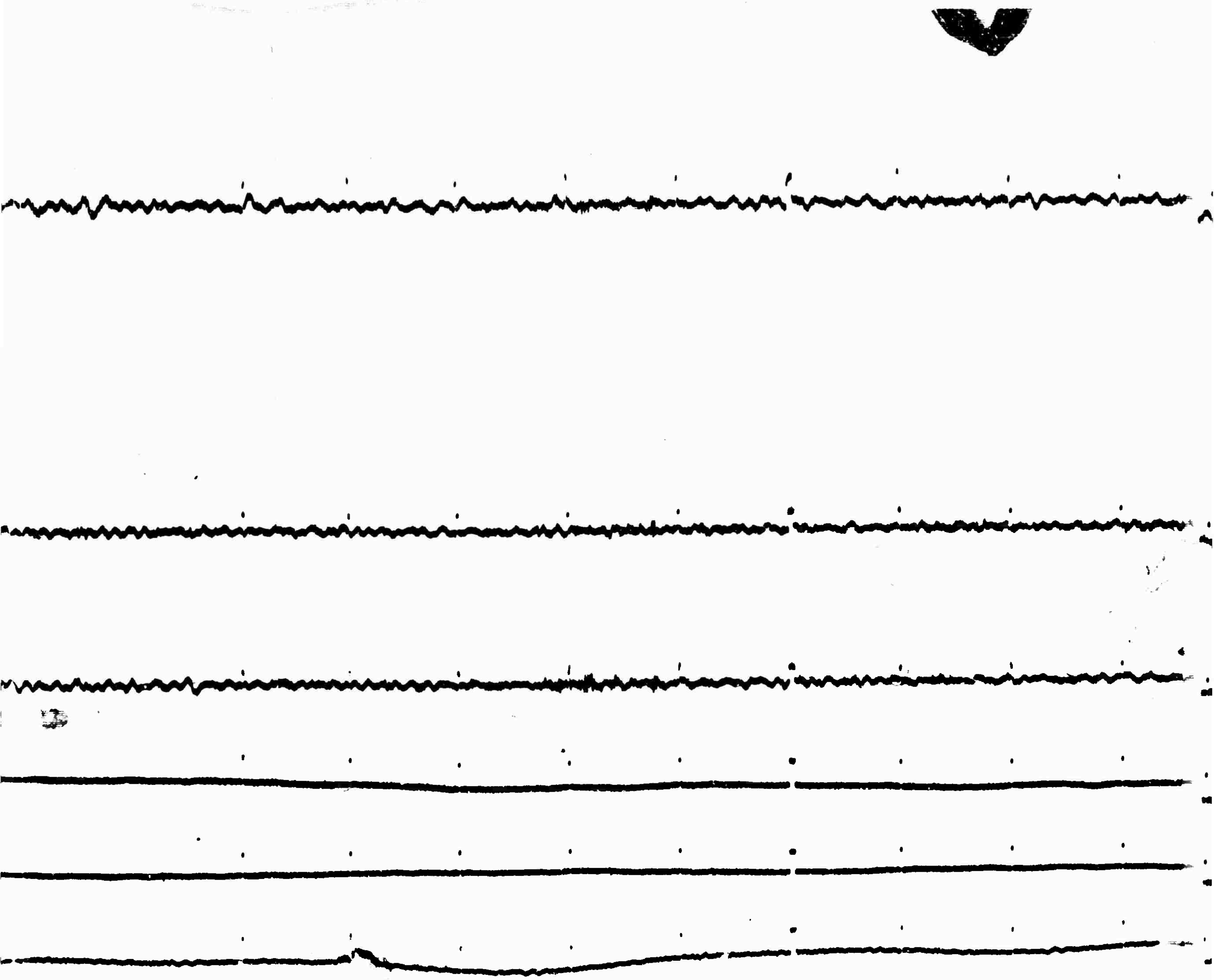
C



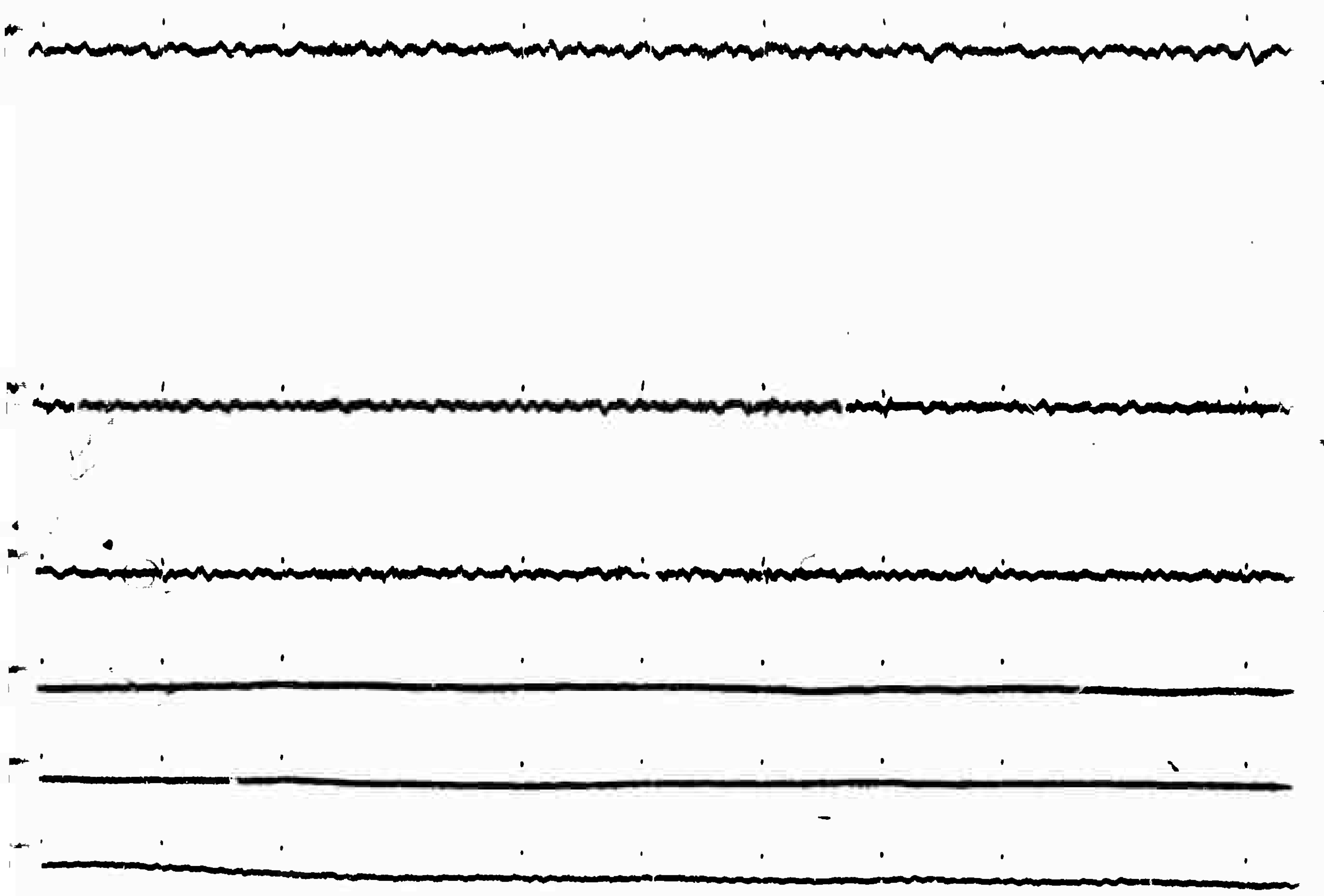
D



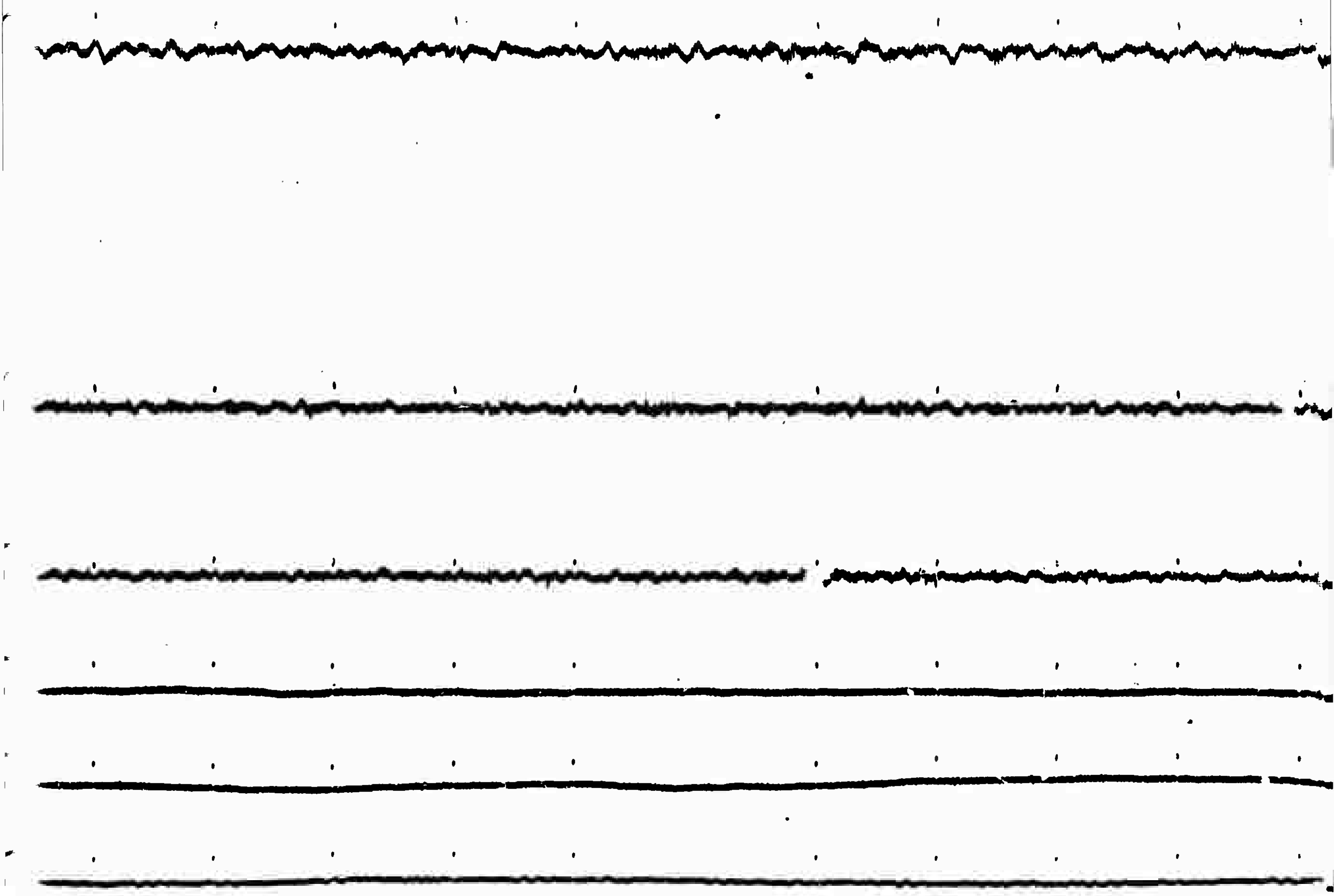
E



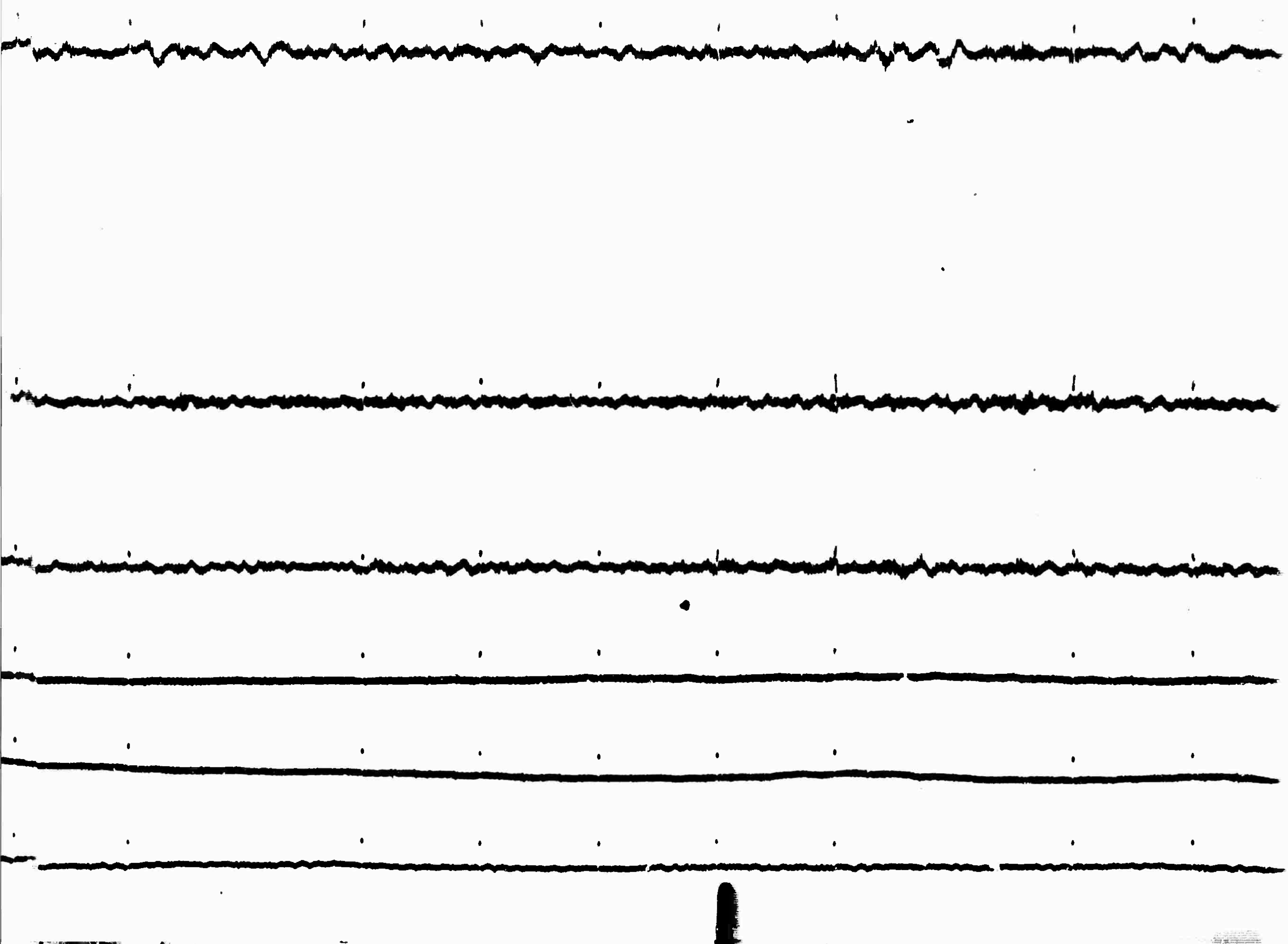
F

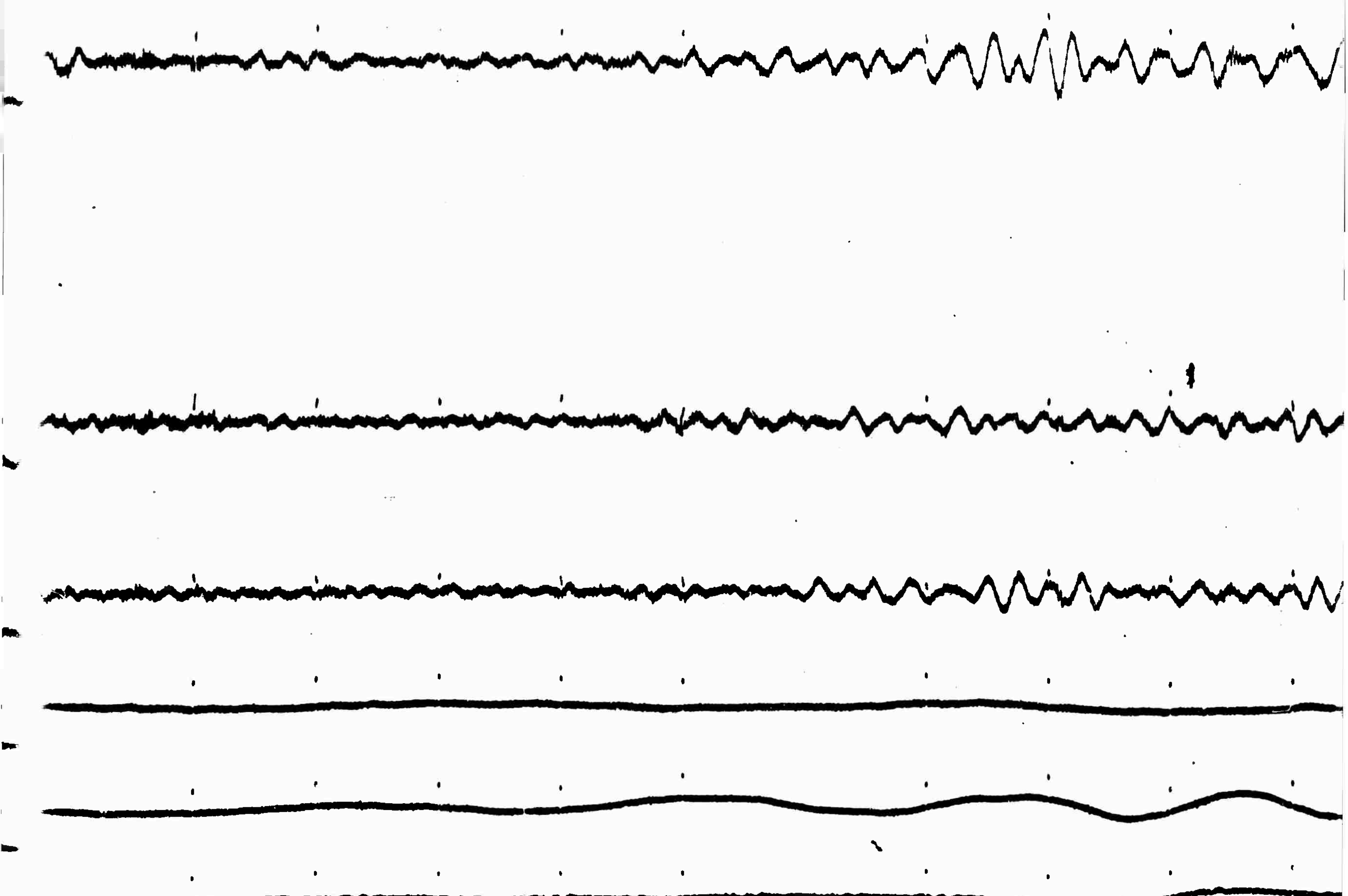


G

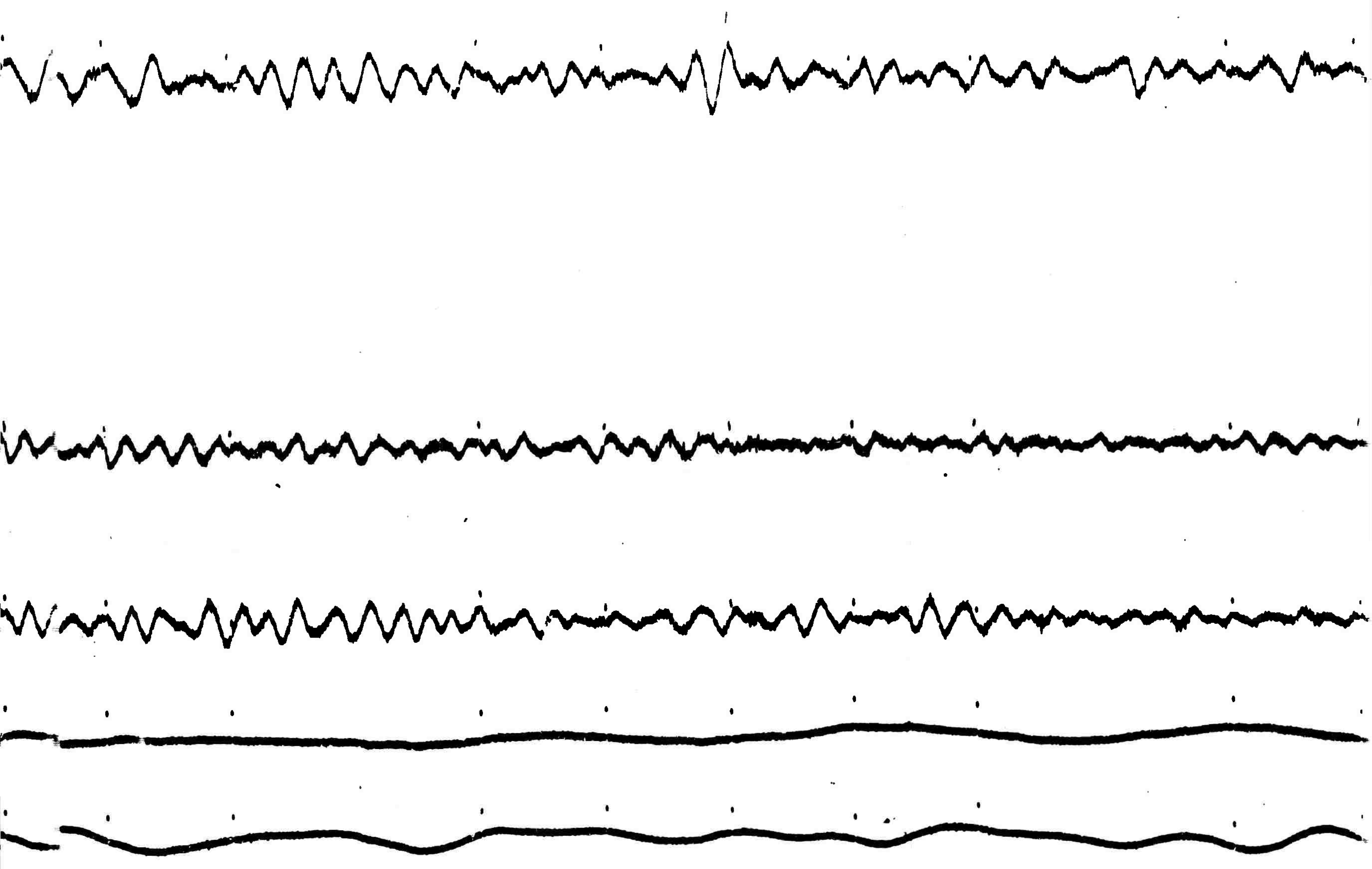


H

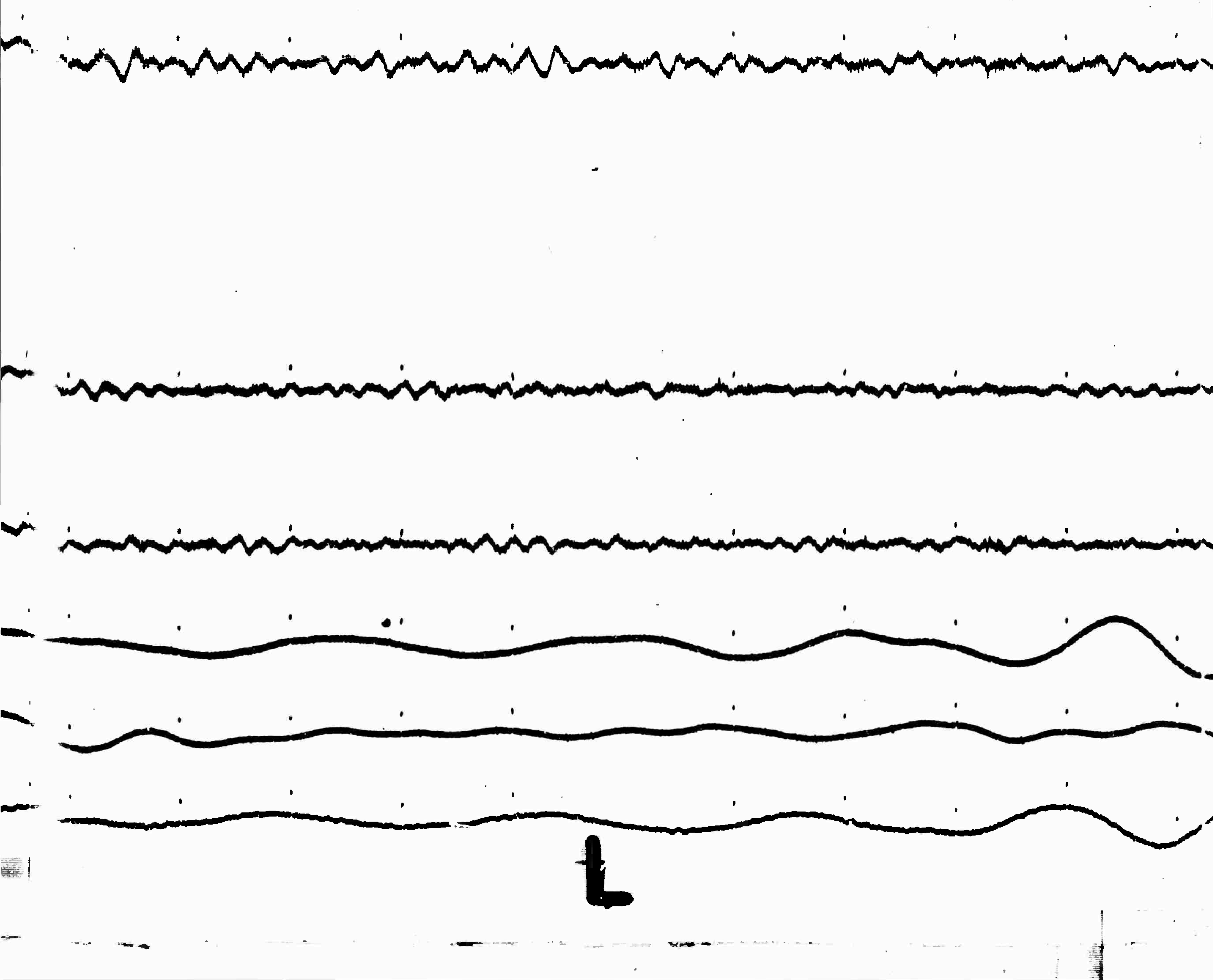


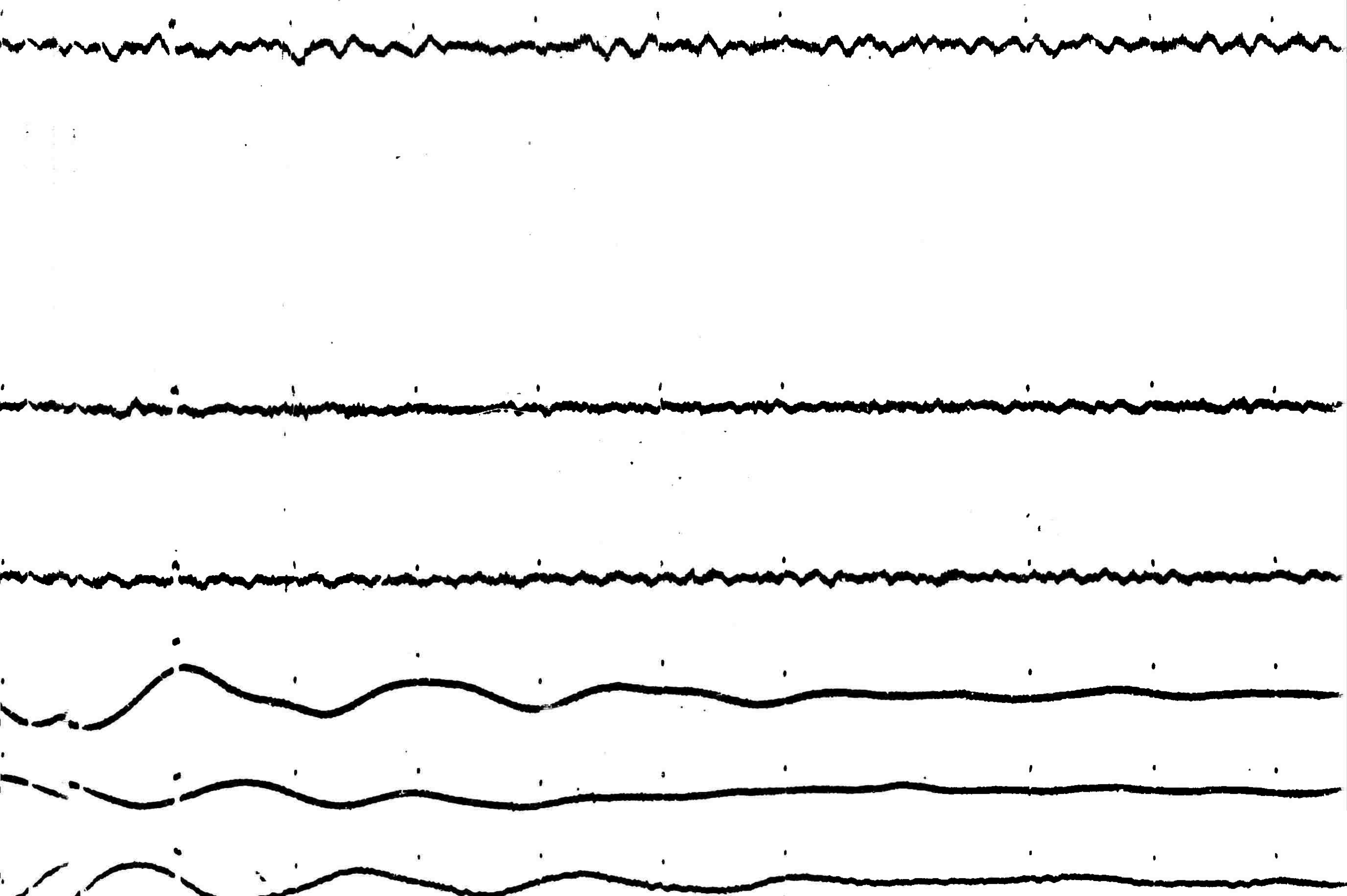


J

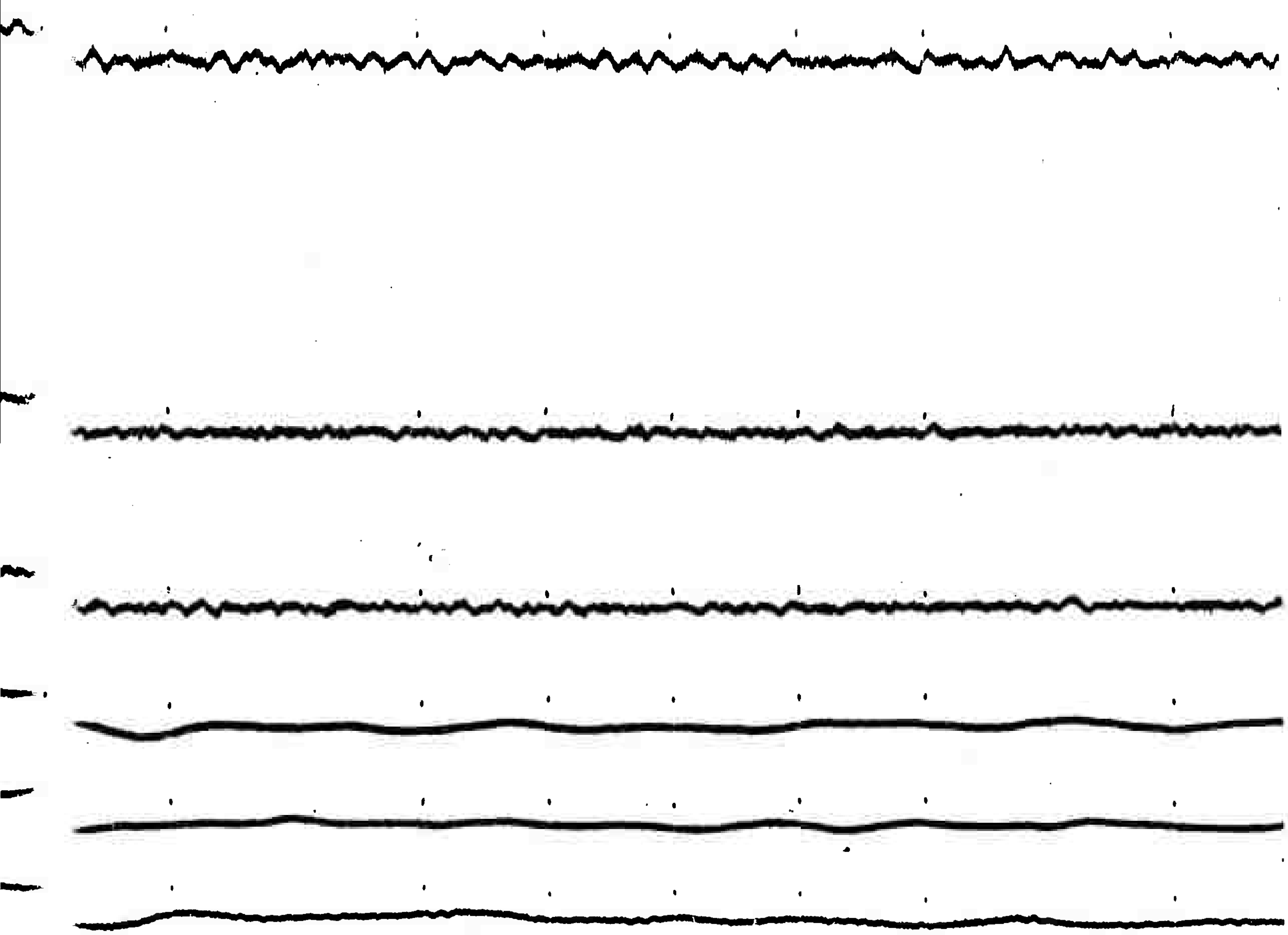


K





M



N

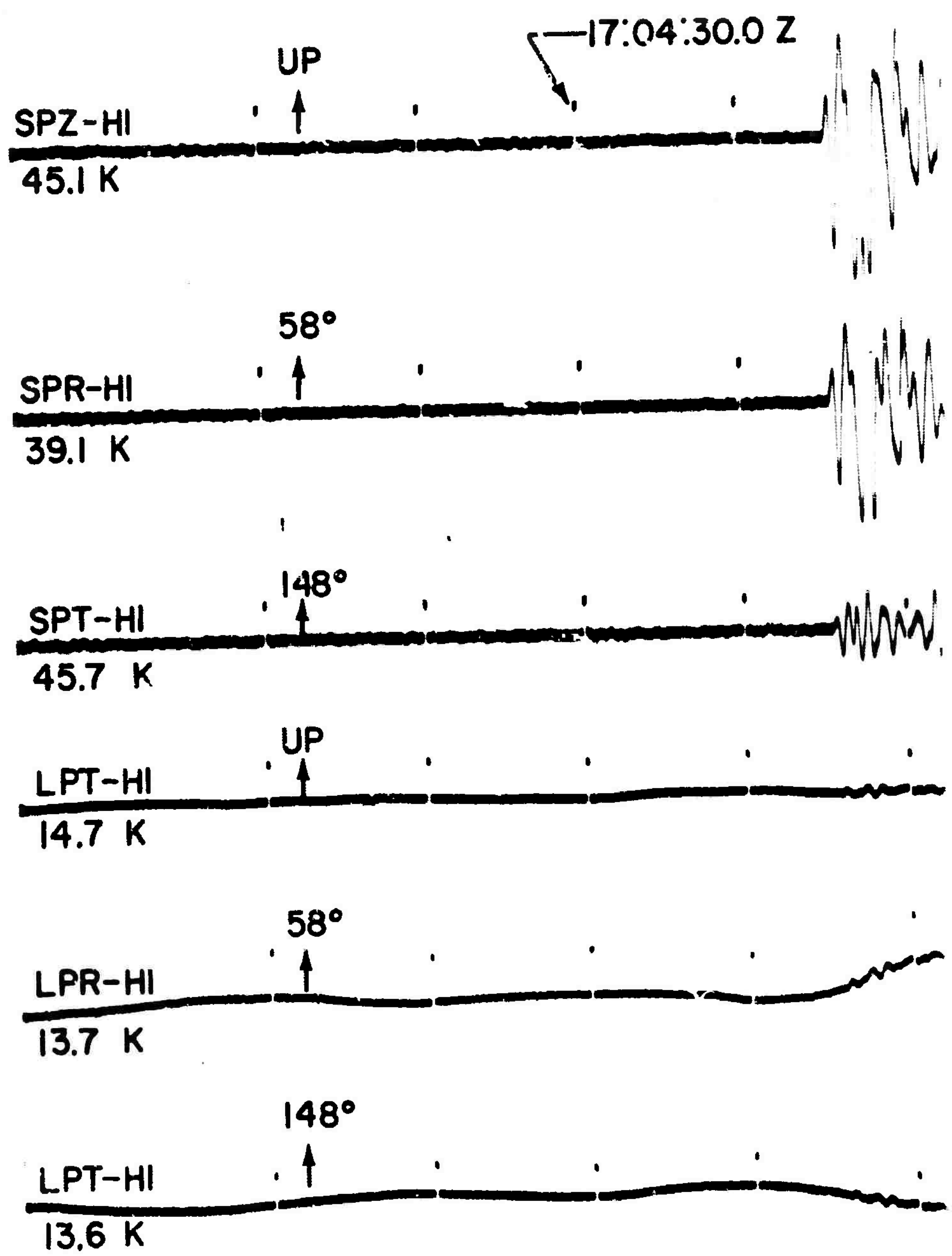
BRONZE

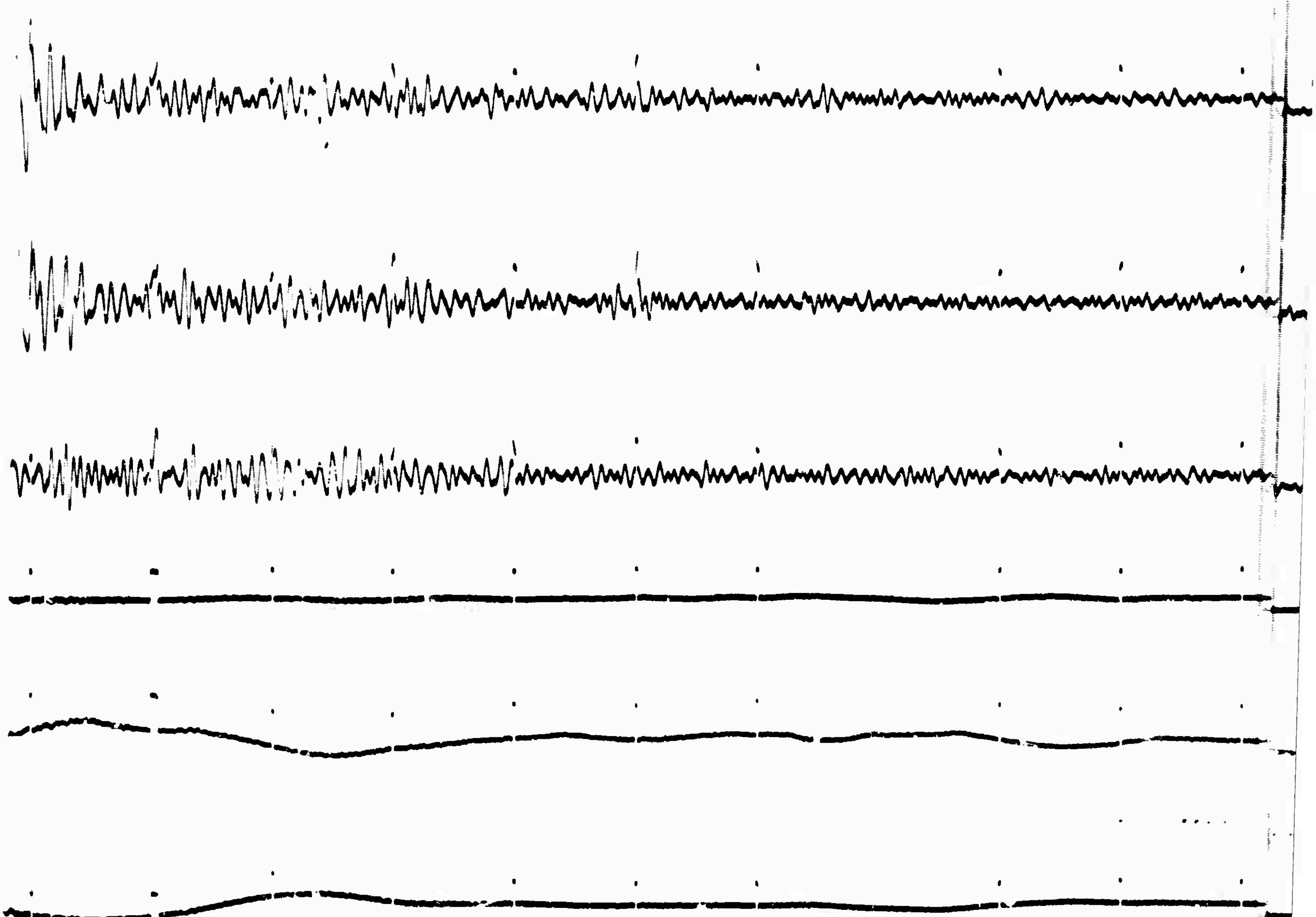
RK-ON

Red Lake, Ontario

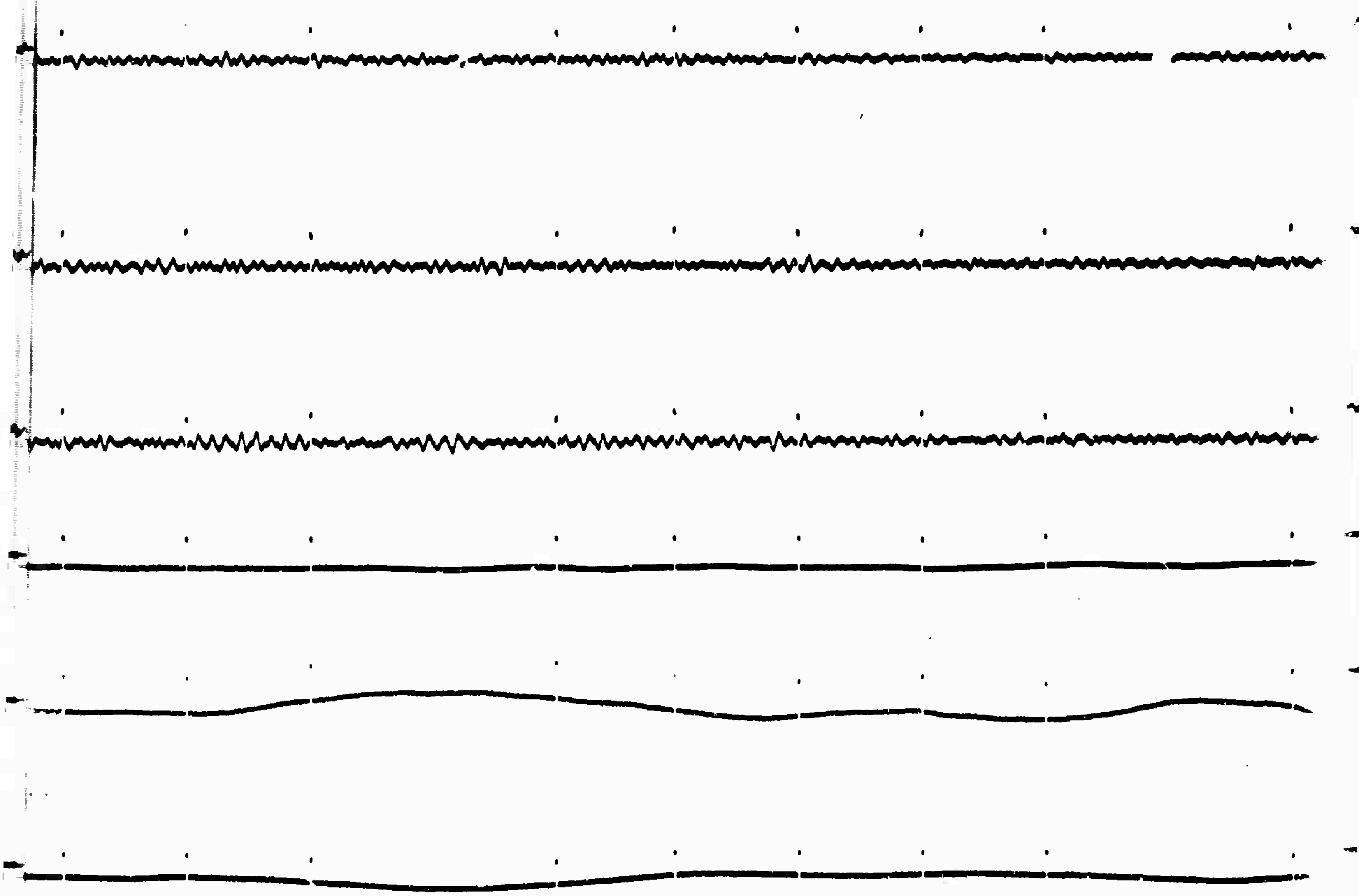
23 July 1965

Δ = 2341 km

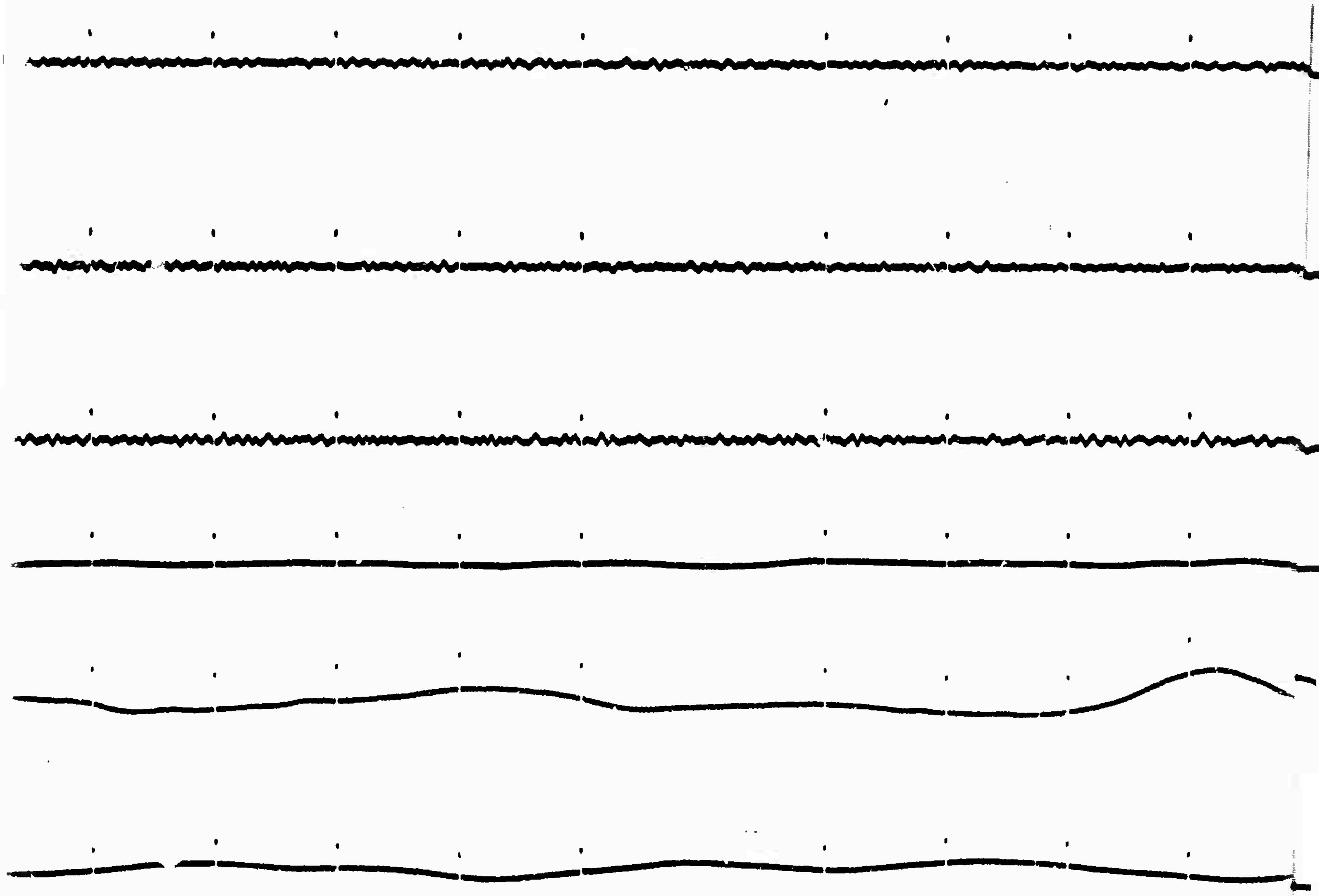




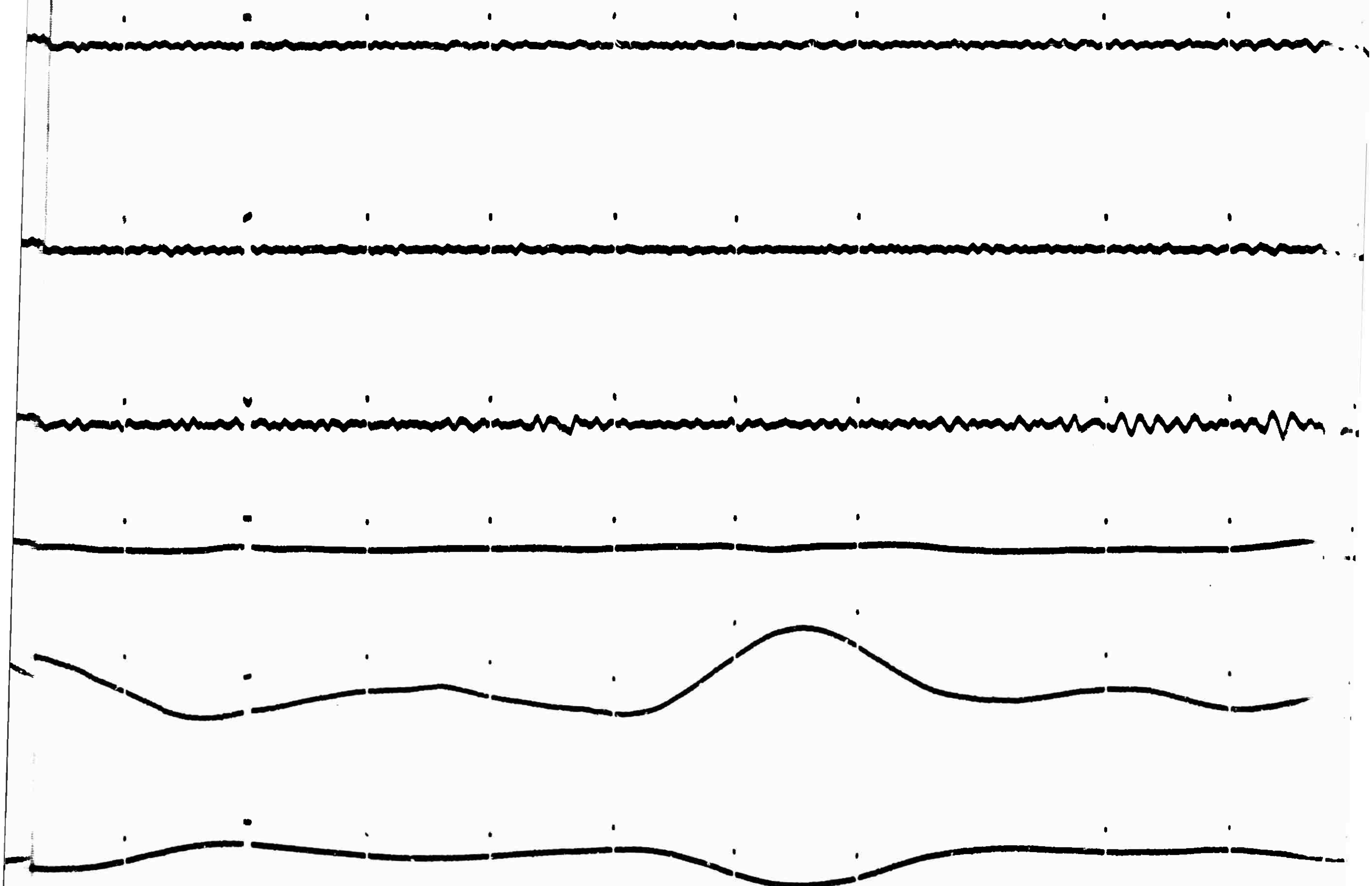
B



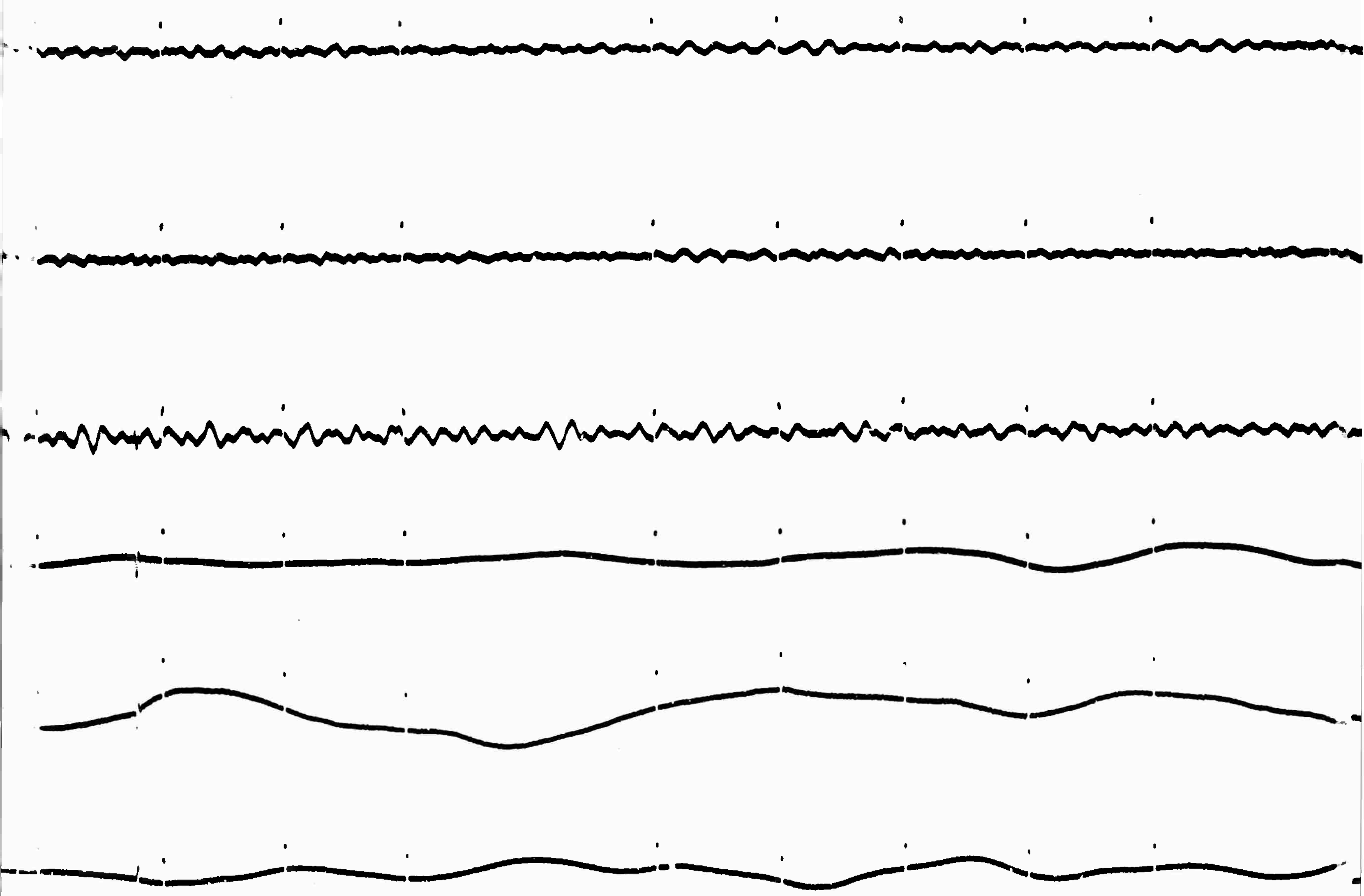
C



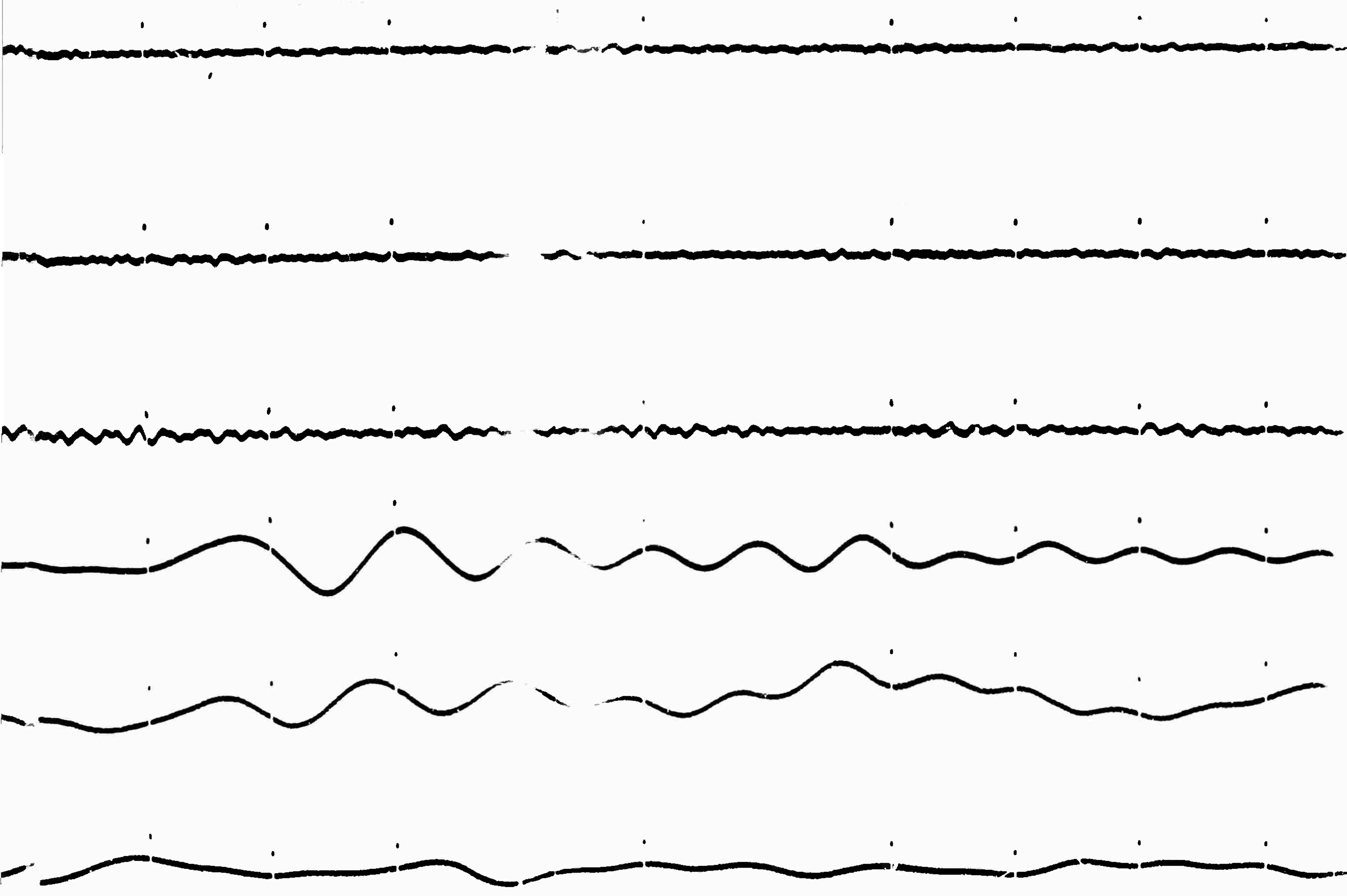
D



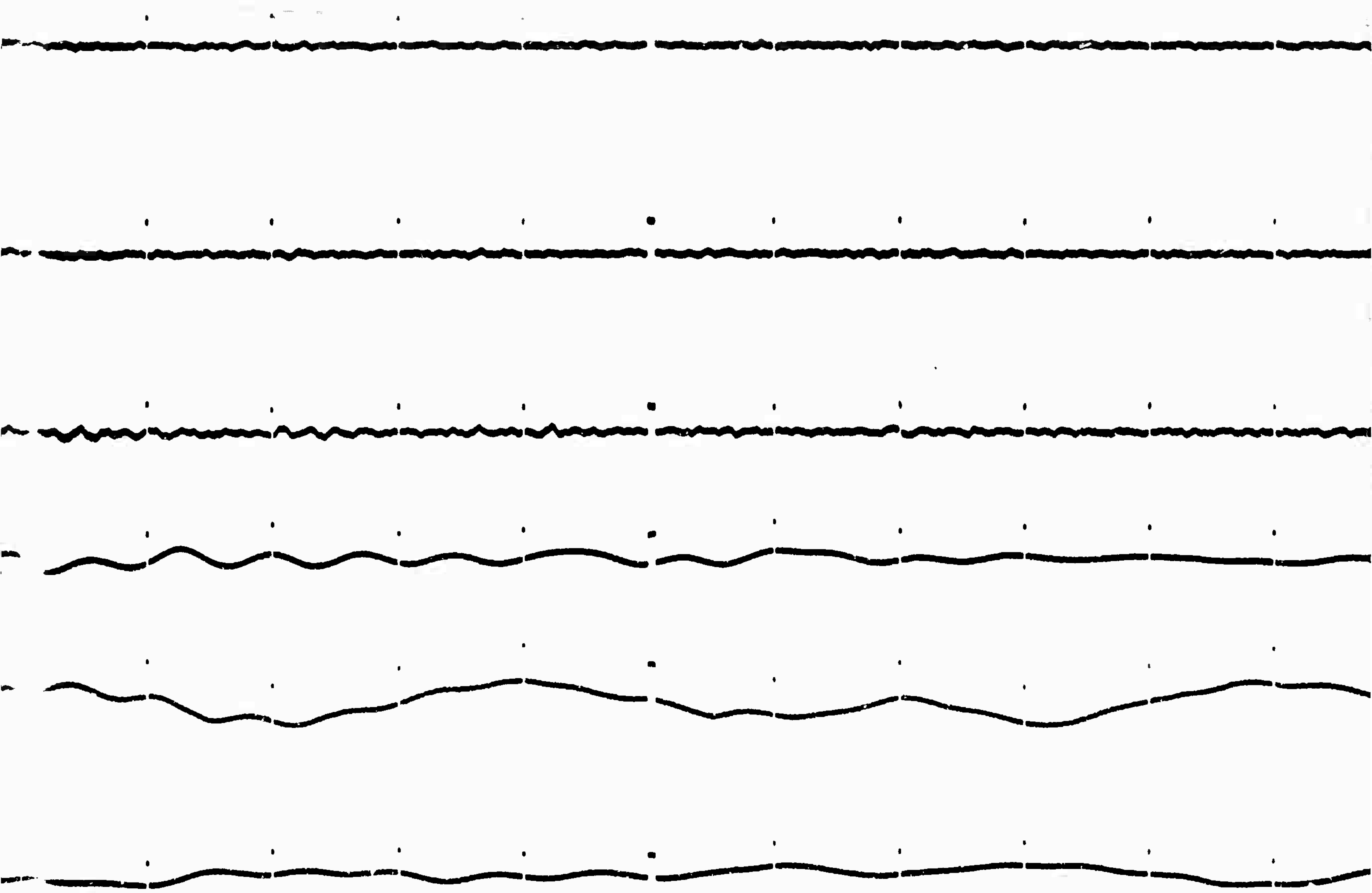
E



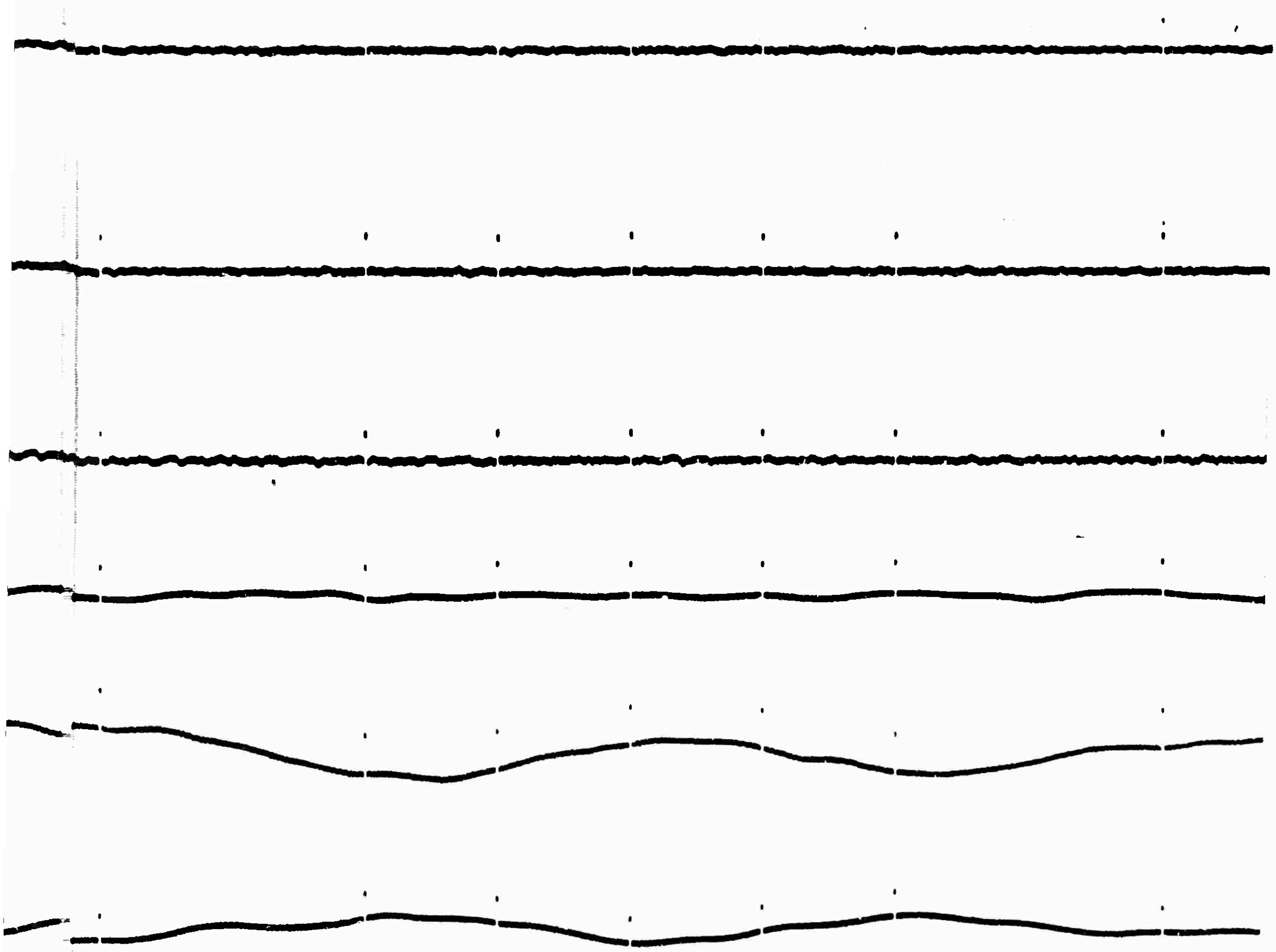
F



G



H



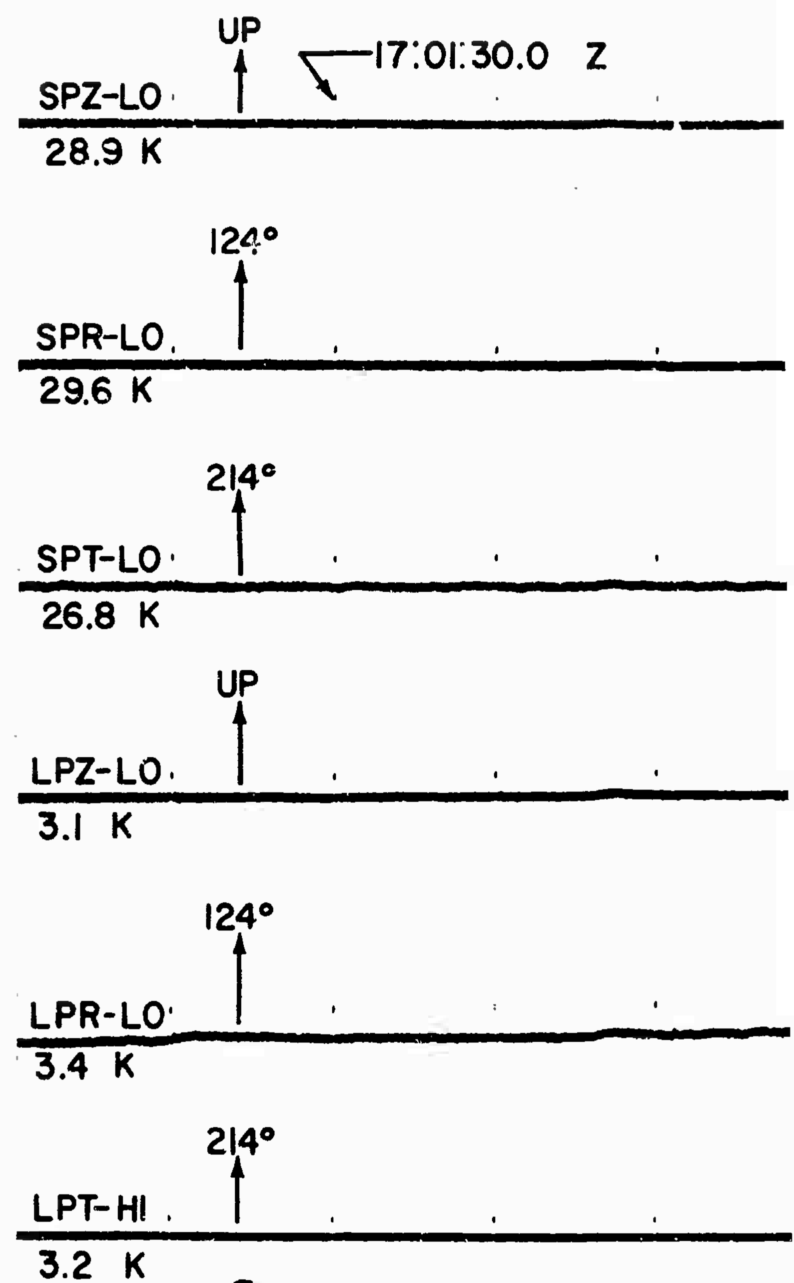
BRONZE

LC-NM

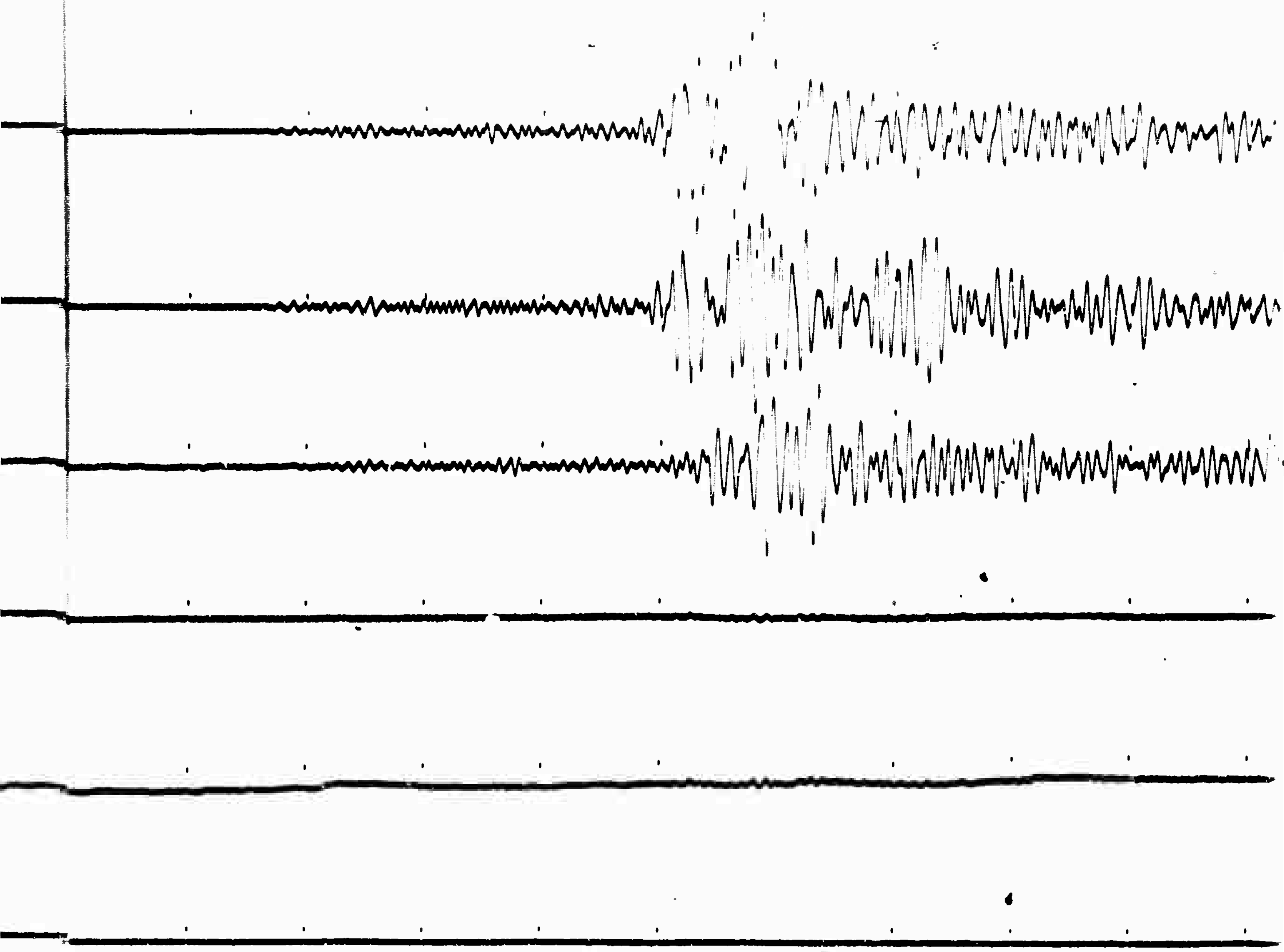
Las Cruces, New Mexico

23 July 1965

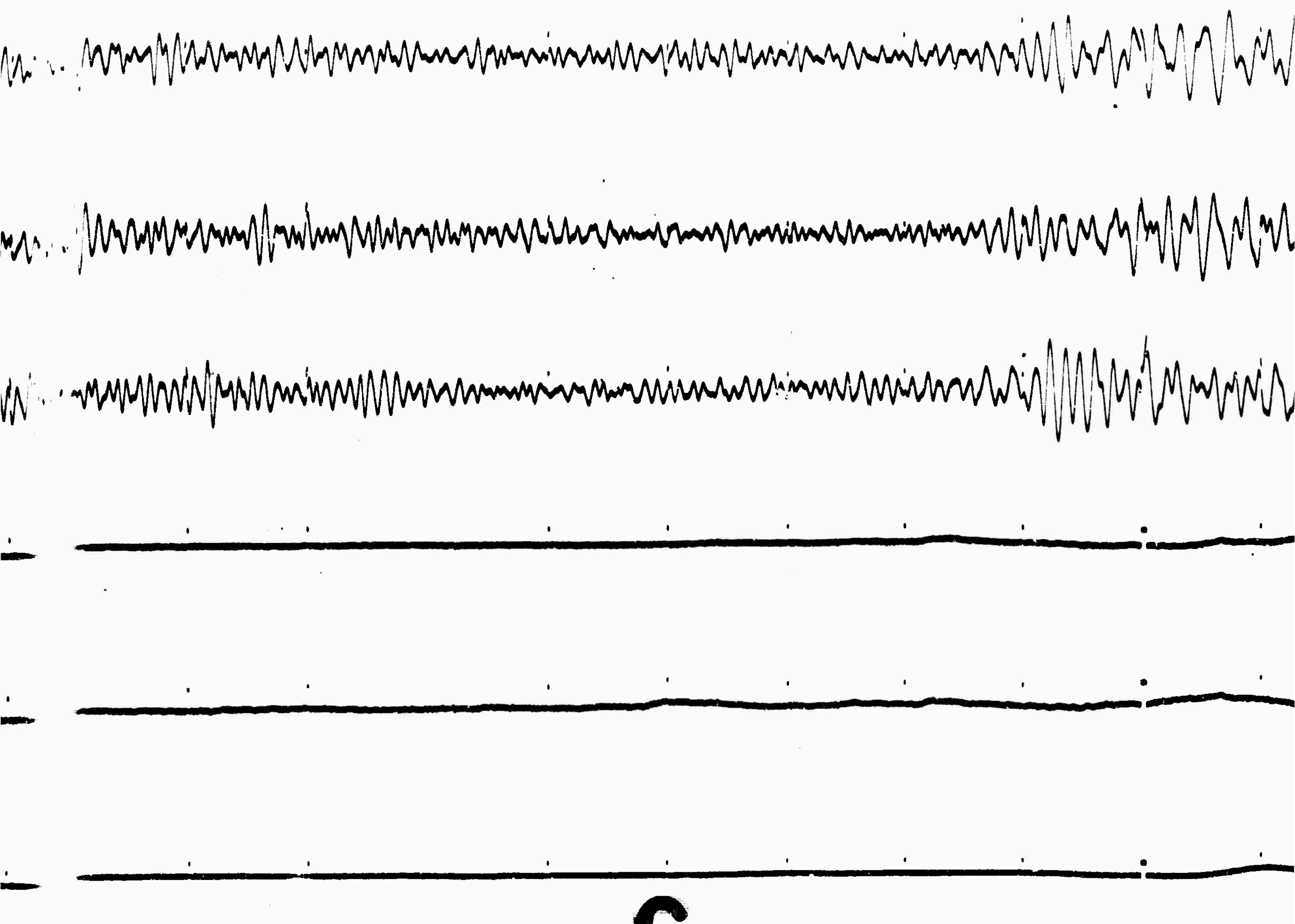
Δ = 1008 km



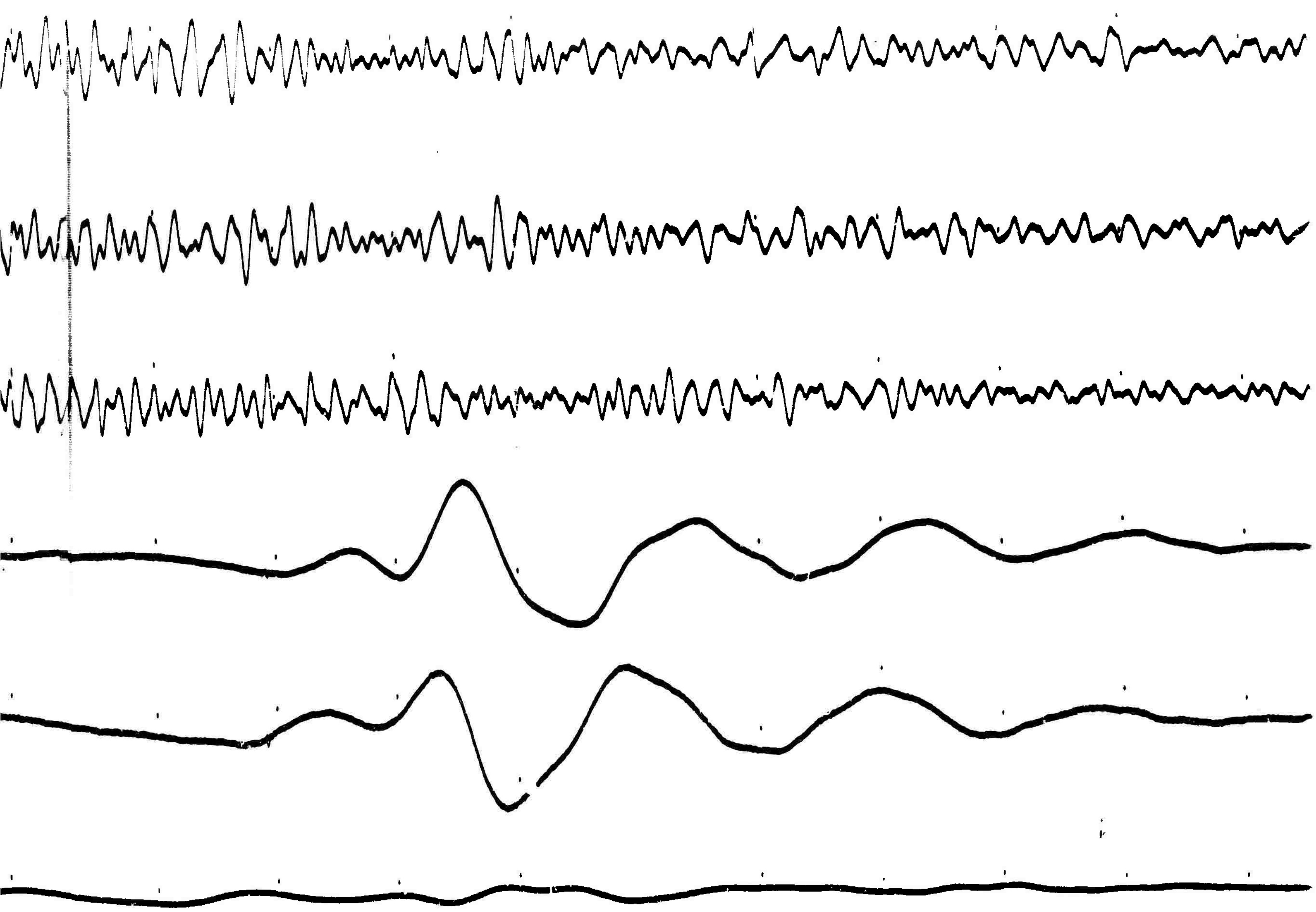
A



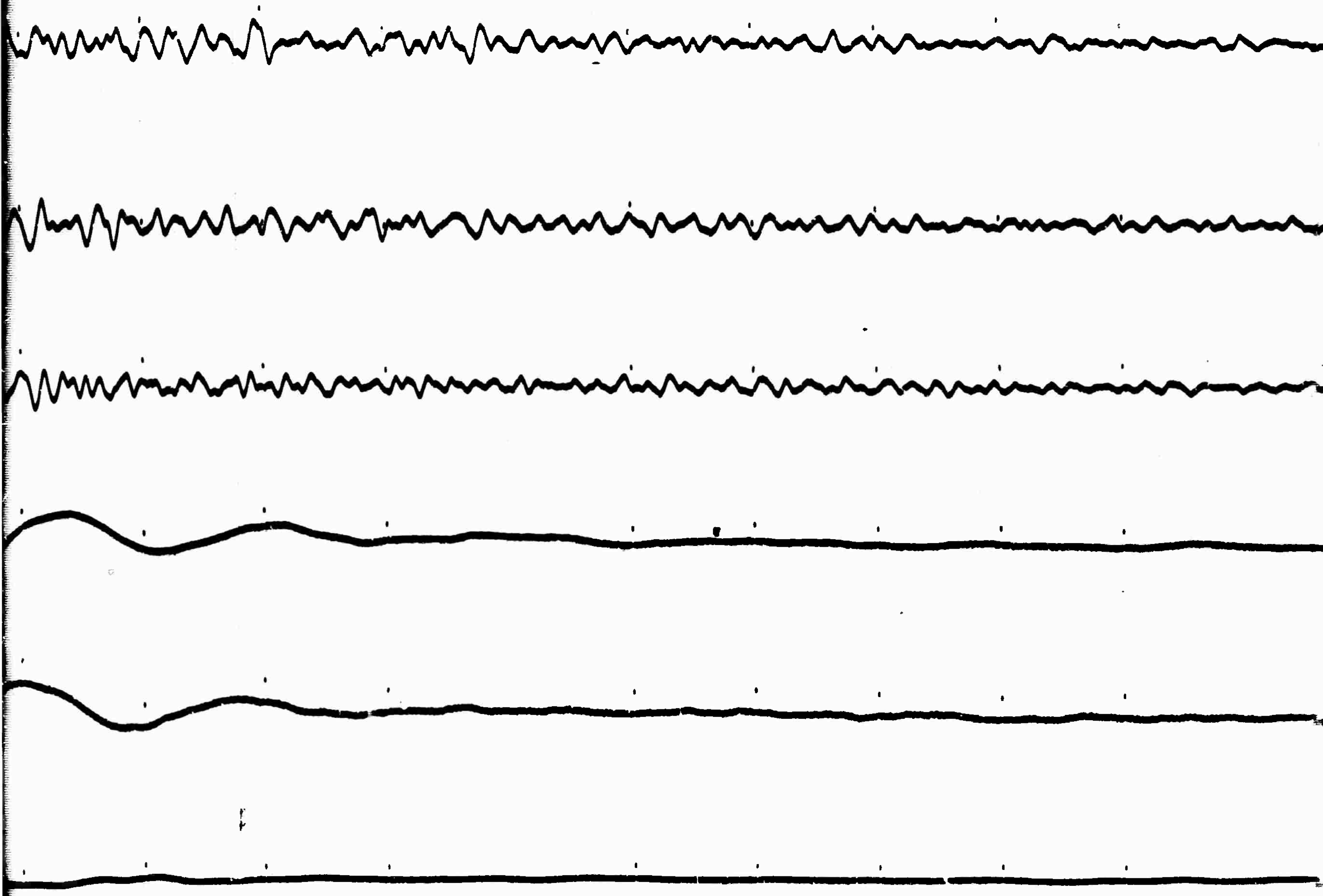
B



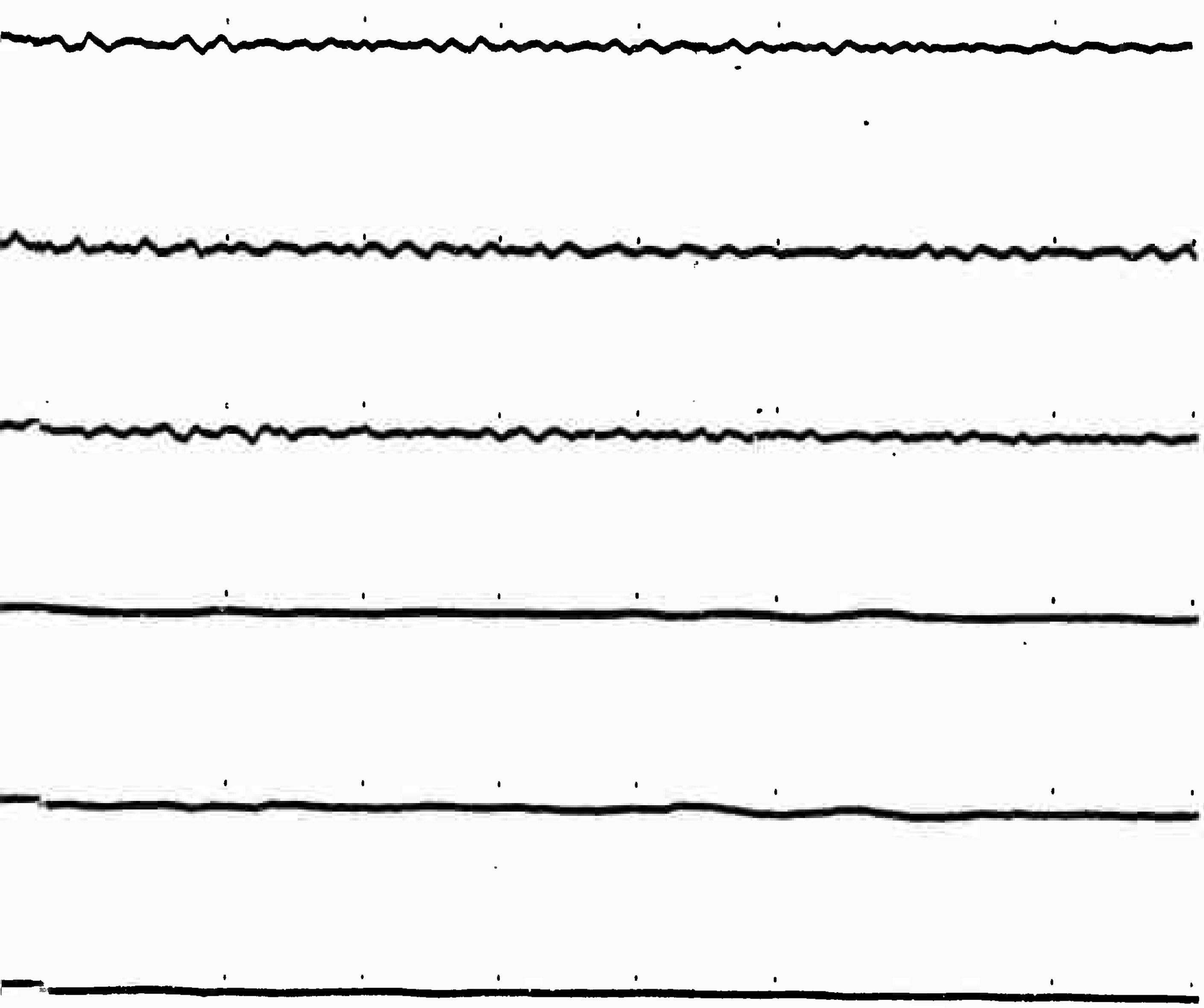
C



D



E



F

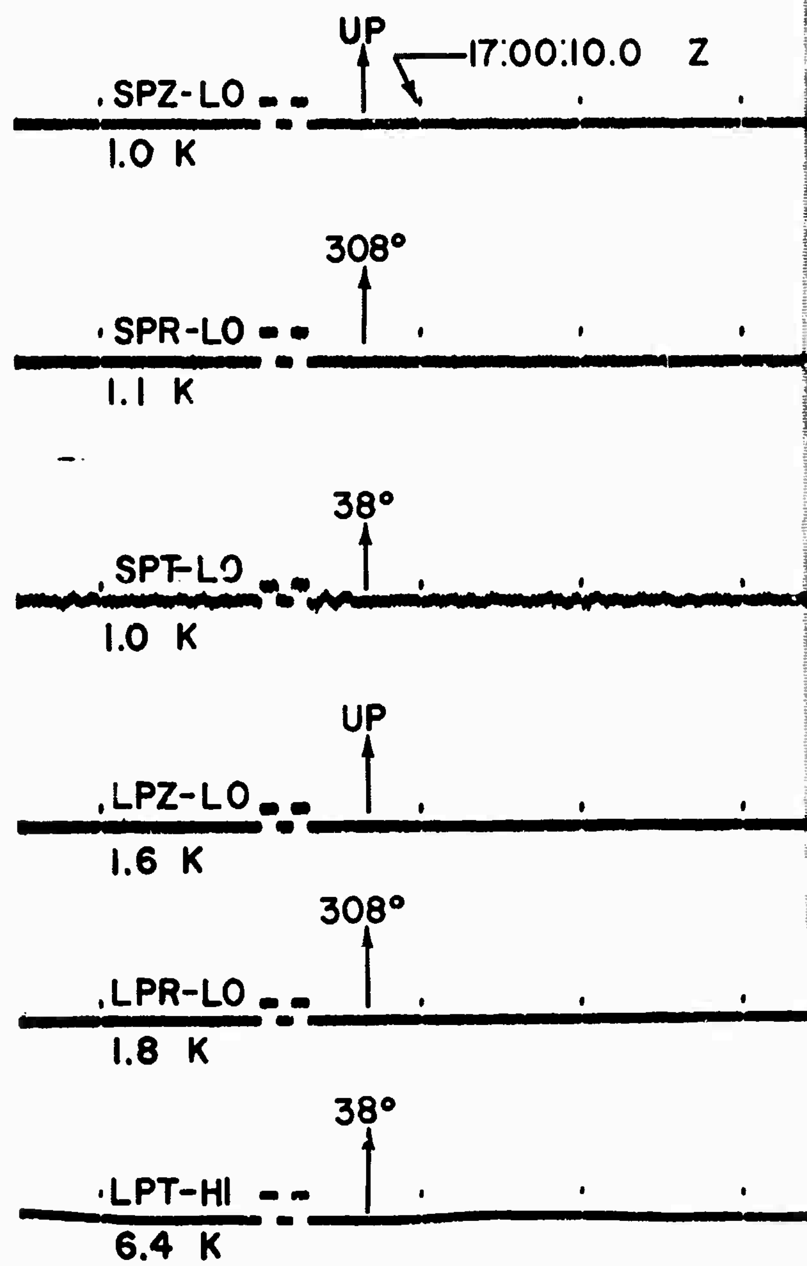
BRONZE

MN-NV

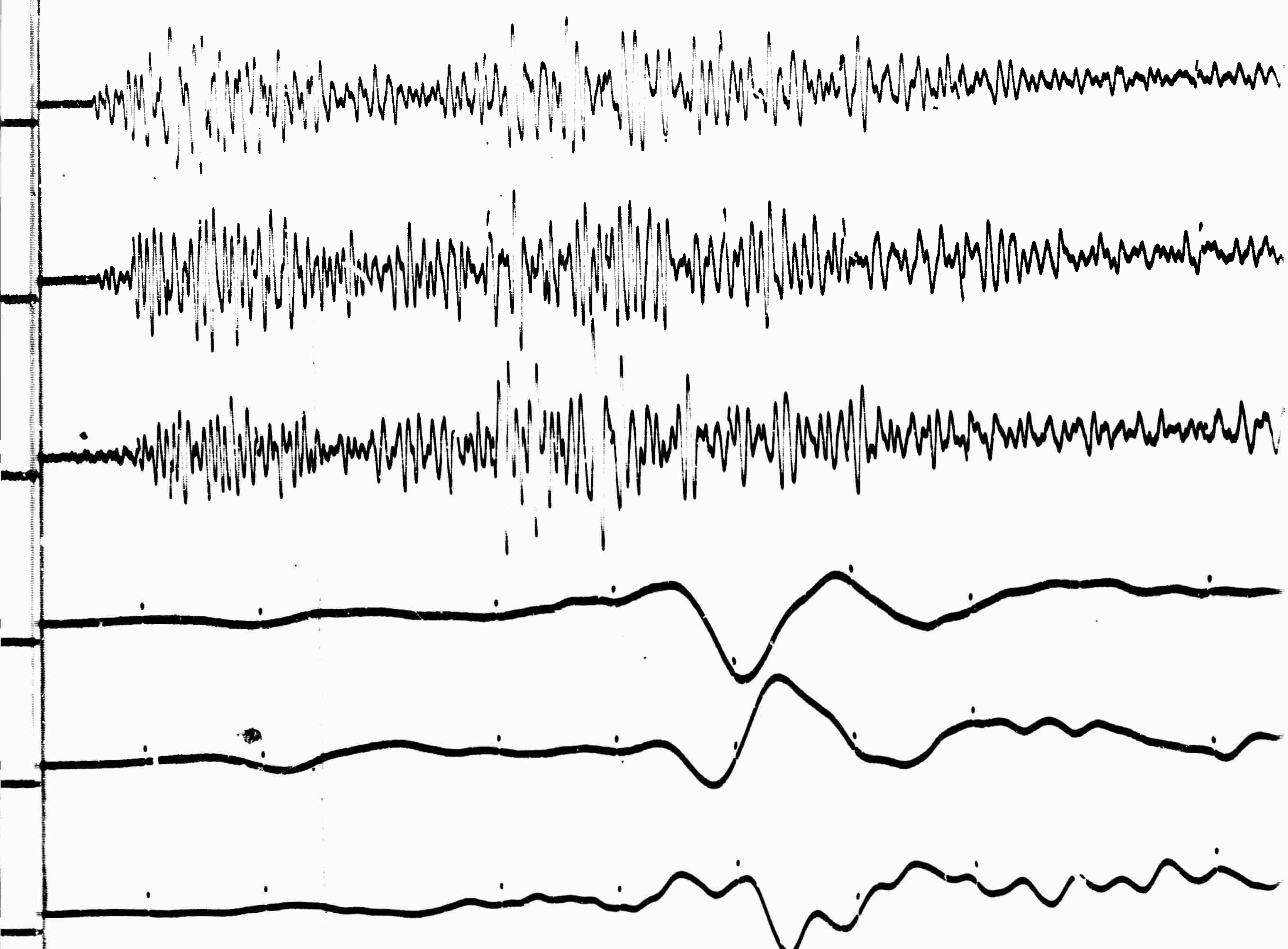
Mina, Nevada

23 July 1965

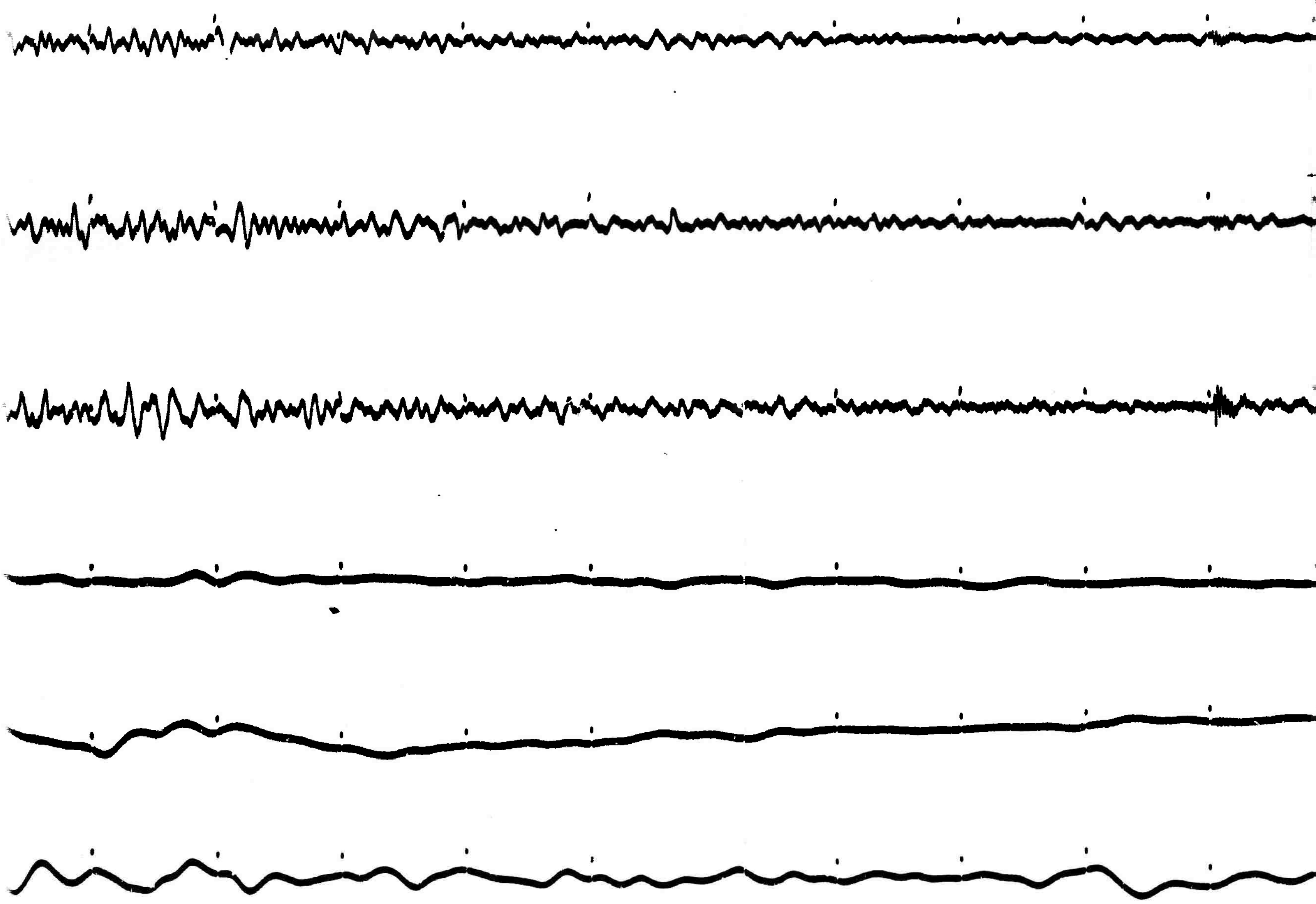
Δ = 238 km



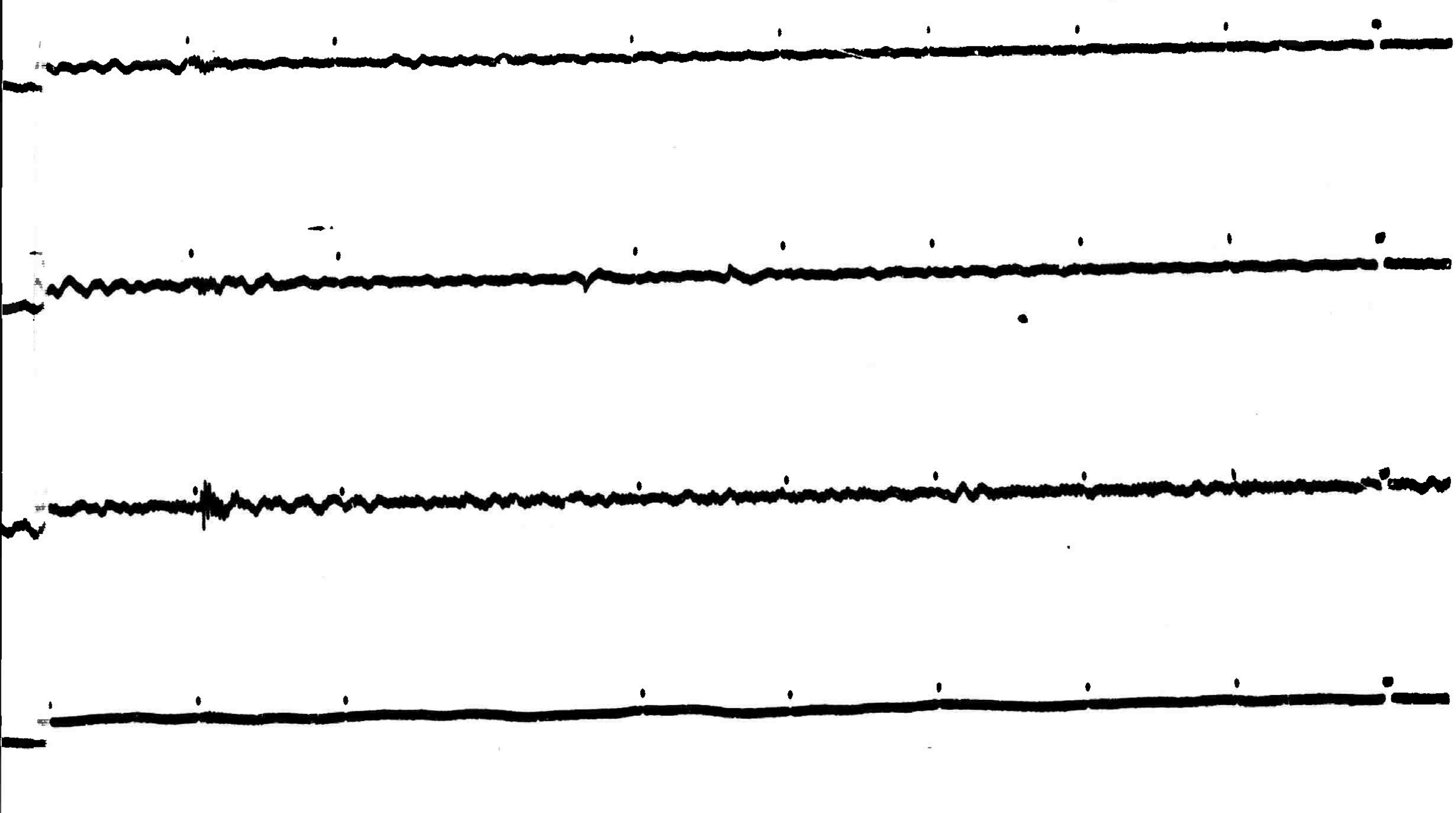
A



B



C



D